Railway Mechanical Engineer

Vol. 101 July, 1927 No. 7

The Mechanical Division report

This issue contains a complete account of the proceedings of the American Railway Association, Mechanical Division, convention held at Montreal June 7 to 10, inclusive. Departing somewhat from our customary practice for those years in which, owing to the absence of the Daily issues of the Railway Age, we publish the full account of the proceedings in the *Railway Mechanical Engineer,* the addressed, papers and committee reports have been grouped into separate articles, each covering a single major subject. This has been done in the belief that such a classification of the wealth of material developed this year at the Montreal meeting would be of material assistance to our readers in readily finding everything pertaining to each subject with as little effort as possible.

Convention hall requirements

Not the least of several factors, which helped to make a big success of the Mechanical Division meeting at Montreal, was the convention hall or meeting room in the Windsor Hotel. It costs many thousands of dollars to compile the committee reports and to make other preparations for a convention of this sort. After all this has been done there still remains the problem of securing an adequate discussion, in order that final and intelligent action may be taken in the interests of the entire group in disposing of the report or recommendations.

It seems strange, in view of the large number of important meetings and conventions which are held each year, that more intelligent and more scientific attention has not been given to the study of convention hall requirements. As a purely cold-blooded business proposition, there is an unnecessary waste of money and energy if a gathering of experts is handicapped in its deliberations by all sorts of annoyances. A reasonably high percentage of efficiency in transacting convention business is unattainable if the meeting room is poorly lighted or ill-ventilated, or if the chairs are squeaky and uncomfortable, or if the acoustics are poor, or if unnecessary noise of any kind is allowed to interfere with the proceedings. Railroad groups hold so many large and important conferences each year, and the railroads are so vitally interested in the development of passenger traffic which is stimulated by conventions, that it might not be out of place if they were to use what influence they possess in getting chambers of commerce or other civic bodies to recognize the value of properly designed and equipped convention halls.

Attendants at the Montreal meeting of the Mechanical Division, and some of them have attended many conventions of different kinds, were enthusiastic over the convention hall at Montreal. It was well-lighted and well-ventilated. The amplifiers—and the fact that the presiding officers insisted upon all those who took part in the proceedings coming to the platform—made it possible for everyone in the room to hear easily and clearly, even in the far corners. The chairs were fairly comfortable and this is quite a consideration for active men who are not accustomed to sit through two long convention sessions each day. There were no unnecessary noises from the street—the meeting hall windows opened on an inner court—and careless and indifferent employees were not in evidence. Indeed, all of the appointments were such that they added materially to the businesslike proceedings and the dignity of the meeting.

Designers of convention halls or meeting rooms could study to advantage the arrangements of the room in the Windsor Hotel. A properly designed and equipped meeting hall should prove a real asset to those communities which are seriously interested in attracting conventions and encouraging them to return from year to year. Incidentally, it is to be hoped that the authorities at Atlantic City will study this question carefully in building the new convention hall in which the Mechanical Division expects to meet next year. It may not be out of place, indeed, for the railroad and railroad supply interests to make some pointed suggestions to that effect, since they will probably make large use of such facilities if they prove suitable and entirely satisfactory.

Mechanical division research

One of the most important objectives of the American Railway Association in the interests of efficient operation is the solution of some of the more pressing mechanical department problems by means of modern research methods. A number of important investigations now under way include those on power brakes, draft gears, tank car devices, car side frames and other car and locomotive devices. In addition to formal tests in university laboratories, a number of problems are being studied in railroad laboratories and in actual road service under the supervision of Mechanical Division sub-committees. Of the latter, experimental loads developed in co-operation with the shippers, is one of importance; retaining valve tests, in which a committee made road studies for weeks on a grade road and developed the need of a standard retainer which is now available in practically its final form; wheel breakage tests and regular periodic contour readings of car wheels are being made at manufacturers' plants by representatives of the wheel committee. In addition much test material is under observation, as for example, the new sulphur cars being constructed for the Atchison, Topeka & Santa Fe.

While valuable results along the line of joint Mechanical Division research have already been secured, this

work should be materially extended for a number of reasons. In general, more impartial, unbiased and carefully supervised tests can be conducted, and then there is a substantial saving in cost due to making but a single investigation, with the expense borne jointly by member roads of the American Railway Association.

The advantages of having research work carried on at university laboratories under the supervision of competent outside directors and Mechanical Division committees of experts in the particular subjects under investigation, are already demonstrated. Reliable results are assured by the employment of trained and unbiased observers, and competitive manufacturers' materials and equipment are treated with the utmost fairness and impartiality. It is interesting to note that in the draft gear tests recently started at Purdue University, Lafayette, Ind., the object is not to rate the draft gears of competing manufacturers in order of respective merit, but simply to develop information about, and general specifications for, a draft gear which will better meet railroad needs. This information will, of course, be of the utmost value to all draft gear manufacturers as well as to the railroads.

Joint research work is valuable to the railroads in other ways than for the information and test data secured. For instance, it is difficult to estimate the amount of favorable publicity which has resulted from the power brake investigations at Purdue. The experiments there are said to prove a constant source of inspiration to the engineering students who come from all parts of the country, and naturally tell their families and friends with pride of the power brake tests being conducted at their university. The news of the intensive effort which the railroads are making to solve the problem of braking trains in the interests of public safety and more economical operation, is still further spread by delegates to the many trade associations which hold meetings annually at the university and either hear about or visit the power brake testing laboratory. It is well that Mechanical Division research work is being generally if slowly extended.

Braking power of freight cars

The solution of the question of revising the present recommended practice for the braking power of freight cars as ordinarily applied to refrigerator cars and other cars of high tare-weight, which has been referred to the Committee on Brakes and Brake Equipment of the Mechanical Division, A. R. A., by the Committee on Wheels, may lead to a revision of the present recommended practices for all types and classes of freight cars. As stated in the report, this type of car does an unreasonably large proportion of the braking for a train under the present system of brake design and as a result, the wheels are subjected to high stresses in the plate and the treads develop brake burns rapidly. It is not surprising that the Committee on Wheels has seen fit to make this recommendation. It is practically impossible to design a wheel with any provision to eliminate overheating. When the brakes on certain cars become inoperative or have a low retarding force, the deficiency must be made up by other cars in the train that may be already overloaded from the standpoint of heat generated by the brake shoe and the wheel.

This condition was discussed at the last annual convention of the Safety Section, A.R.A., at Chicago and was considered to be the principal cause of the 542 derailments during the past year. This question was also discussed in considerable detail by F. K. Vial, vice-president and chief engineer, Griffin Wheel Company, Chicago, in a paper entitled "The Standardization of Braking Power of Freight Cars" which he presented at the annual convention of the Air Brake Association, held at Washington, D. C., late in May. He stated that "75 per cent of the accidents due to overheated wheels can be eliminated without expense if the subject is given a little thought and a simple remedy applied to overheated wheels."

The wide variation in braking power on cars of different types cannot help but cause overheating of the wheels on a comparatively few cars and less than normal heating on the majority of cars in a train. The present recommended practice for the braking power of freight cars was formulated in the late seventies when all freight cars were very much alike and when it was not difficult to produce uniform brake retardation. Since that time, the 30-ton, 40-ton, 50-ton and 70-ton capacity cars have been developed which, with the addition of abnormally heavy cars for special service, has introduced decided irregularities in the rate with which energy is dissipated on the treads of the wheels. The problems created by this tendency in the development of rolling stock are not new and have led to recurrent discussions during a long period of years. In this case, however, as in others, a situation which has long been unsatisfactory ultimately becomes intolerable as conditions become more severe. While the wheel conditions as effected by braking may not yet be intolerable, it is evident that they are approaching that condition and the matter is of sufficient importance to justify the committee on Brakes and Brake Equipment to attack it vigorously. Mr. Vial's implication that the remedy is simple will probably not meet with complete acquiescence, but, coming from such a source, it cannot be allowed to pass unchallenged unless perchance investigation proves that the implication is fully justified.

Periodic maintenance of locomotives

In discussing the subject of locomotive repairs, the Committee on Locomotive Utilization of the Mechanical Division in its report at the Montreal meeting again stressed the importance of making the proper repairs to locomotives when in the terminal for monthly certificate inspection so that the locomotives will run to the next certificate period without a road failure and with a minimum of running repairs. This is an old subject about which much has been written and said, but it still remains a live mechanical department problem which never seems to be satisfactorily solved. There are many factors that contribute to improper locomotive maintenance, some over which the mechanical officer has no control.

One factor over which some mechanical officers have little control is the monthly appropriation for locomotive maintenance. A cut in the maintenance budget means only one thing: a general reduction of the amount of work performed on the equipment. If the maintenance budget is reduced in proportion to the service required of the power, this is only sound business, but if the reduction is made arbitrarily without due consideration to traffic conditions, the resultant effect is detrimental to the maintenance and performance of the locomotives in service.

The fact that railroads have done much to properly maintain their power and thereby reduce to a minimum locomotive failures with their resultant loss of road time and increased transportation cost, is substantiated by the comments A. G. Pack made at the Montreal meeting, to the effect that the locomotives throughout the United

States during the last fiscal year were in better physical condition than ever before since the inception of the Bureau of Locomotive Inspection. However, the fact that the committee in its report on Locomotive Utilization, comments on the lack of sufficient maintenance of locomotives at engine terminals, indicates that there is still room for improvement.

The periodic performance of running repairs recommended by the Committee on Locomotive Utilization has decided advantages over the former method of making all running repairs to power based on inspectors' and enginemen's daily reports. However, such a system of maintenance cannot be satisfactorily worked out if sufficient funds are not provided to make all repairs needed at each monthly inspection to carry the locomotive through the next 30 days, because the enginehouse foreman, in order to keep within the limits of an arbitrary monthly maintenance budget, is forced to omit much of the work not required to maintain the immediate serviceability of the power. In order to put the power in proper physical condition so that it will run from month to month with a minimum of unscheduled running repairs, the mechanical department must be provided with some control of its maintenance budget. After a system of periodic roundhouse maintenance is once thoroughly installed, there is little doubt but that maintenance expenditures will be less and power conditions better than under the old system of putting off till another day all work except that most urgently required for the next trip.

Freight car repair shops

The report of the Committee on Shops and Engine Terminals at this year's Mechanical Division Meeting brings to a conclusion a two-year study on the design of car shops particularly adapted to the maintenance of freight cars. This year's report especially deals with the type of permanent repair shop adapted to the use of the progressive system of car repair. That the progressive system has proven successful is evidenced by the fact that over 50 per cent of the freight cars in service in this country are now overhauled by this system.

It was suggested during the discussion of this same committee's report a year ago, that in view of the growing tendency towards railroad consolidation and the centralization of equipment repairs, individual roads should go rather slowly in the construction of large shops of a permanent nature. One great advantage of the progressive system has been the possibility of utilizing facilities of a more or less temporary nature in the handling of freight car repairs.

In the conclusion of this year's committee report, it is stated, "To operate the progressive system successfully necessitates shopping at one time a large number of cars of the same series requiring the same general class of repairs."

Permanent car repair shops, in many instances, necessitate the movement of cars over great distance in order to concentrate a whole series at a given point for repairs. Assuming that it might be economical to repair cars of different series at a greater number of points on the road established in some relation to the demands of particular loading territories, it seems worth while for mechanical officers to investigate the possibilities of further developing the progressive repair system, keeping in mind the advantages of facilities of a sufficiently temporary and flexible nature to permit abandonment without great loss. Unlike the permanent shop, which in most cases represents a large capital investment, these temporary repair shops can function efficiently on a given class of work as long as the occasion demands. Should changing conditions make the concentration of repair work at another point more economical, these temporary facilities can be abandoned and re-established elsewhere with little loss to the road.

One of the most important factors is the problem of material handling and the handling of parts during the progress of the work. Recent developments in material handling devices such as electric trucks and portable electric cranes fill the requirements of this work without the construction of facilities of a permanent nature, and in addition may be easily transported from one point on the road to another as occasion demands.

The use of the progressive system has undoubtedly contributed in a large measure to the reduction in the percentage of unserviceable freight cars. Its continued development should result in a substantial saving in the costs of freight car maintenance. If by its future development, a large part of the work can be handled by temporary rather than permanent facilities, requiring large investment, the railroads should profit by a further reduction in the percentage of unserviceable equipment and by greater savings in maintenance costs.

New Books

Tests of the Fatigue Strength of Cast Steel. *By Herbert F. Moore, research professor of engineering materials, in charge of the investigation of the fatigue of metals, Engineering Experiment Station, University of Illinois, Bulletin No. 156, published by the University of Illinois, Urbana, Ill. 20 pages, illustrated. Price 10 cents.*

The extensive use of steel castings in stress-carrying members in machines and structures and especially their use in railway rolling stock, has called attention to the lack of available data on the fatigue strength of steel castings; that is, the ability of steel castings to resist repeated stress without being fractured. Bulletin No. 156 is the first report of a series of tests being conducted by the Engineering Experiment Station, University of Illinois, in co-operation with the American Steel Foundries, of the fatigue strength of cast steel. These tests have been in progress since 1919. Although the information secured in the first series of tests is somewhat limited, the lack of data on the strength of cast steel is believed to justify, for the benefit of the users, the publication of the results.

The scope of this investigation covers only the study of the strength of cast steel as a material and does not take up the study of the effective strength of this material in different parts of a casting, modified as it is by internal strains, minute cracks and inclusions of dirt, slag, oxides, etc. Bulletin No. 156 gives an analysis of the chemical composition and heat treatments of the cast steels tested, in table form. Tables and charts are also included showing the results of Brinell, Charpy, repeated-stress tests made on a rotating-beam machine, and repeated-impact tests made on a double-hammer machine, built in the shops of the materials testing laboratory of the university. As a general conclusion the bulletin states that, "the results of these tests indicate that under favorable casting conditions and by the use of suitable heat treatment, cast steel can be produced having a strength under either static load or repeated load only slightly less than the strength of rolled steel of similar chemical compositions and characteristics."

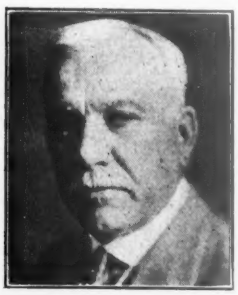
Montreal convention of the Mechanical Division

An unusually strong program of reports, papers and addresses presented during four-day meeting

The eighth annual meeting of the American Railway Association, Mechanical Division, was the first convention of this organization and its predecessors ever held in Canada. The meeting was held at the Windsor hotel, Montreal, Que., June 7 to 10, inclusive, and the program, which included an unusually large number of papers by outstanding engineers and railway officers on subjects allied to, but outside of the scope of the work of the standing committees of the organization, required both morning and afternoon sessions for the first three days.

Tuesday morning's session was opened with an invocation by the Rev. Canon Shatford. The opening address was delivered by the Right Honorable George P. Graham, formerly Canadian minister of railways. At various sessions during the meeting a number of other constructive addresses were delivered before the convention. These addresses, together with the technical papers and committee reports, will be found in several articles in each of which is grouped all of the material dealing with the same general subject. Other addresses of general import by President Aishton of the American Railway Association, and Interstate Commerce Commissioner Frank MacManamy, are included in this article, together with an account of other matters of general interest.

Address of the Right Honorable George P. Graham



G. P. Graham

Your chairman has said that I was Minister of Railways in the trying time. The world had trying times and the railways were affected. During these lean times Canada embarked on the greatest experiment of national ownership that was ever attempted. I was the victim of that experiment for some years, when it was unpopular, and it was hard to make men believe that it was possible for a country to own and operate a railway. But times have changed and our two great railway systems in Canada are now enjoying the sunshine of prosperity. I think that the Canadian Pacific and the Canadian National railways are managed as competently as any transportation companies in the world.

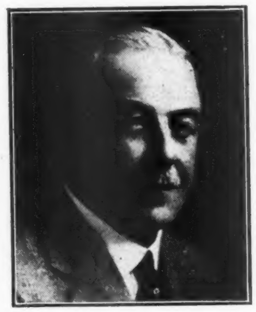
The success of the transportation companies furnishes an index of the prosperity of the country. Car loadings may be dry reading to most people, but the record of how many cars were loaded and with what they were loaded each week is very interesting not only to the railway companies, but to the business men generally in any country.

The world ought to move judiciously in its continued efforts to curtail the incomes of transportation companies. Service must be paid for at a reasonable rate. The men who put their labor into the transportation business will never return to the remuneration they had before the war, and it would not be a good thing for any of our companies or any of our countries if they did. A new era has arrived in that respect and we must adjust ourselves to the conditions which we have. It is a mistake on the part of the press or the public to endeavor to compel transportation companies to transact business at less than a fair profit.

We cannot, on this continent, hope to build our various countries or nations to that point which should be their object of attainment, unless by unity of action. Geography, if nothing else, has made it impossible for you in the United States to get along without us in Canada, or for us to get along without you.

Such gatherings as this bring men together from various nations on this continent, and you find when you sit down to discuss your problems that they are practically the same, and always will be. We cannot develop as we should unless we work to a certain extent in unison and harmony, and I am glad to know that the American Railway Association, through its members, is working in harmony in order to better the conditions of transportation. You men have to do with the equipment. On you we depend not only for comfort but for safety. At the present time men and women on this continent travel with greater speed, greater ease, more comfort, and greater safety than they ever did before in the history of transportation.

Address of R. H. Aishton



R. H. Aishton

The following is an abstract of the address of R. H. Aishton, president of the American Railway Association:

The railroads of the United States and Canada have made greater strides in the past four years in the development of their mechanical facilities than ever before in the history of the railroads.

As a result of this development the railroads of North America are being operated with more economy and with greater efficiency than ever before. Corollary to this, the public in both the Dominion of Canada and the United States is receiving the best transportation service ever accorded them by the rail carriers in those countries.

The railroads in 1926 handled the greatest freight traffic in their history but they not only did so without car shortage or other transportation difficulties but also with an ownership of fewer freight cars and locomotives on their lines than in the year before. This year they own still fewer cars and locomotives but owing to the fact they are constantly replacing obsolete equipment with cars and locomotives of more modern type and with greater transportation capacity, and the fact that both

freight cars and locomotives are being used more efficiently today then ever before, the American Railway Association believes it possible to handle the traffic of the United States for some time to come with at least 100,000 fewer freight cars than are now owned by the railroads. This statement is based on the assumption that there will be a continuation of the present economical use of freight cars and also an increase of one ton in the average load per car, which, with public co-operation, can be easily attained.

This recommendation constitutes only one of the many concrete results which have been attained by the railroads due to the large capital expenditures which they have made in the past few years in order to insure the maintenance of adequate transportation.

Not content with what has already been accomplished, however, the railroads are endeavoring to bring about still further improvements with a view of realizing still greater efficiency and economy in operation. This is prompted by the fact that in addition to what has already been accomplished by them in the way of savings, they must work for further economies which must come mainly from improvements in operation brought about largely by improved mechanical devices.

Numerous railroads, for instance, have found that electrically controlled switch machines at remote points will not only facilitate the movement of trains but will also bring about savings both in labor and in train operation which alone will pay for themselves within approximately three years. By the development of automatic signals and the elimination of delays in terminals, the movement of trains has been expedited without the necessity for additional large capital expenditures. Stronger and better freight cars are being constructed today than ever before with a view of increasing their capacity without increasing their weight. This is shown by the fact that freight cars now being built by the railroads and which have a capacity of 50 tons, weigh less than the 40 ton capacity cars which the Railroad Administration built some years ago.

The trained scientist and the mechanical engineer are now playing a greater part in the operation of the railroads than ever before. Housed in laboratories, often miles from the main lines of railroads, they are conducting extensive research work designed to bring about still further improvements and efficiencies in operation.

Co-operative railroad regulation

By Frank McManamy

Member, Interstate Commerce Commission

Photo Clinedinst

F. McManamy

The present magnificent transportation facilities are simply the inevitable result of the application of the brain and energy of an aggressive people to the problem of developing a vast continent. To those concerned with the present performance and the future policy of railroad transportation, the record of the past century of progress possesses more than mere historic value. There are lessons to be learned from past performances. This is true not only with respect to the physical design and operation of equipment and facilities, but it is equally true with regard to the broad questions pertaining to management and the relations of the railroads to the public.

What are the principal events that led up to and the influences which brought about the methods of operation and regulation of railroads which exist today, and are they co-ordinated so that they can function in the way that will to the greatest possible extent protect and promote the interests of the public which, after all, is the only legitimate reason for their existence? The answer to the latter question cannot properly be given by you or by me, because each of us, in our respective capacities, shares the responsibility for results, therefore what I shall say will relate to the former question and will partake somewhat of the nature of a progress report or description of methods to aid those whom we are all endeavoring to serve in reaching an intelligent conclusion with respect to the latter question.

(Mr. McManamy here explained that American railway development can be divided into three distinct periods: namely, that in which expansion was encouraged by the government; that in which questionable financial methods and rebating, with its attendant evils, were indulged in; and the present or third period, in which government regulation, made inevitable by conditions common in the second period, is in force. He then gave a brief resumé of the organization and activities of the Interstate Commerce Commission, which was created by an Act of Congress approved February 4, 1887.)

I wish now to touch upon the method adopted by the Commission to bring about harmonious co-operation between shippers, carriers, and the Commission, as the representative of the public, so that the laws may be administered without unnecessary formal proceedings, either in the courts or before the Commission, without friction and at a minimum of expense.

In its third annual report, dated November 30, 1889, referring to the method of administering the law, the Commission said:

> In consideration of the motives that usually influence human conduct in great business affairs in which the whole country is concerned, it was believed that at the outset at least, and until leading principles were fairly settled, it would be more profitable for the Commission for the most part to lay down rules of conduct for the present and future, and by frequent conference and intercourse with managers to have those rules observed, than to devote its time mainly to instituting and conducting penal and criminal prosecutions. * * *
>
> It is not intended to be implied that official prosecutions should not be instituted directly by the Commission. The enforcement of the law by the methods provided for in the act is a part and a material part, of its duty, and prosecutions constitute one of those methods. It is only meant that prosecutions in the courts, inaugurated and carried on by the Commission, would necessarily have superseded other duties that were more useful and apparently more important.

In every way consistent with proper administration of the law, the policy above outlined has been not only continued but developed by the Commission until at present co-operation between all parties at interest to bring about a proper observance of the requirements of the laws has developed to a point which at that early day was not possible. In fact, the increase in the scope of the Commission's work since that declaration of policy was made has been such that without co-operation developed to its fullest extent the work assigned to the Commission by law would be impossible of accomplishment. To illustrate the extent to which this co-operation is carried, I will refer to a few of the activities of the Commission and the corresponding activity of the carriers in cooperation therewith.

Accounts and statistics

Our Bureau of Accounts and Bureau of Statistics have always invited not only carriers' organizations, but other representative bodies or individuals interested in transportation matters, to submit suggestions and recommendations tending to improve or better harmonize with the public needs the Commission's accounting and statistical regulations.

In connection with the revision of steam road classi-

fications now in progress, close contact is also being maintained by these bureaus with the committee on accounts and statistics of the National Association of Railway and Utilities Commissioners.

Such organizations as the United States Chamber of Commerce, National Industrial Traffic League, chambers of commerce of different cities which have evinced interest in the classifications, members of the faculties of the principal universities, various publications specializing on transportation matters, and prominent public accounting firms have been invited to submit their views and comment as to the tentative classifications for steam roads recently drafted.

Other organizations, such as the National Council of Traveling Salesmen, have made application to the Commission for an opportunity to express their views as to what the accounting classifications should provide. They will be afforded full opportunity to do so.

It has consistently been the Commission's policy to develop through the Bureau of Accounts and the Bureau of Statistics the fullest information as to all proposed changes in accounting and statistical requirements. Constructive criticism is invited and is always welcomed from whatever source.

Responsive to this, the principal classes of carriers subject to the interstate commerce act have created organizations composed of the chief accounting officers of the respective companies such as the Railway Accounting Officers' Association, the Association of Water Line Accounting Officers, or similar organizations, for the very purpose of co-operating with the Commission through its several bureaus in improving accounting methods, standardizing forms, and generally promoting efficiency in accounting. These organizations, through their appropriate committees, confer with representatives of our Bureau of Accounts and Bureau of Statistics as to the disposition of important accounting questions that are constantly arising, and particularly in connection with the adoption of new accounting rules or statistical regulations. The co-operation of the carriers' accounting organizations is especially helpful in connection with the revision of the accounting classifications undertaken periodically in order to bring them up to date and make them responsive to changes in legislation. Such a revision is now in progress in the course of which representatives of the Bureaus of Accounts, Statistics, and Valuation have been meeting with the special committee on revision of the Railway Accounting Officers' Association and also with that body's committee on general accounts.

Formal and informal cases—traffic

Our Bureau of Formal Cases in one year disposes of some 1,500 complaints by means of formal proceedings. During the same period informal adjustments brought about through our Bureau of Informal Cases of matters which otherwise would develop into formal complaints numbers approximately 8,000. These adjustments are brought about by means of correspondence with the parties at interest or by conference with appropriate committees or other authorized representatives of the different parties.

Our Bureau of Traffic is constantly settling through informal negotiations controversies between shippers and carriers which otherwise would result in litigation. The bureau realizes the great difficulties under which carriers labor in preparing rates and regulations for publication in a manner which will meet the numerous requirements of law. In examining tariffs the policy is followed of directing attention to all apparent infractions of the law or the rules with suggestions intended to be helpful as to how such practices may be corrected and avoided in future at minimum expense of time and money to the interested carriers. In granting authority to publish rates on short notice and to waive the ordinary rules of publication to meet emergencies, the bureau deals in a sympathetic way with the problems and difficulties met with by the carriers and follows as liberal a policy as possible subject only to reasonable safeguards against discrimination as between shippers or carriers. Full opportunity is afforded by the officials of the bureau for personal conference with officers and agents of the carriers with respect to any of the various applications continually filed by them. Where it is not possible under the law to grant precisely what the carriers seek, it is the practice of the bureau to indicate other forms of relief which may adequately meet the needs of the carrier and yet be consistent with the law. A number of employees of the bureau are constantly engaged in the examination of tariffs with a view of suggesting plans to the carriers for simplifying such publications, so that they will be less expensive to print and file and will, when filed, more clearly and adequately state the rates, thus eliminating one important source of loss to carriers, namely, overcharge claims resulting from ambiguous tariffs and from the accidental publication of rates and privileges not intended.

In matters relating to tariffs, as with other matters, the carriers and shippers maintain appropriate committees covering such important factors as tariff publication, weighing, demurrage, reconsignment, and similar matters so that the work may be handled promptly and unnecessary expense and litigation avoided. The rules for the publication, filing, and posting of tariffs were devised after consultation with experts of the carriers. No changes are made in such rules without opportunity being afforded carriers to make suggestions, and such suggestions are followed in so far as consistent with the public interest and the Commission's duties under the law.

Service

Our Bureau of Service through its force of service agents is constantly holding conferences with shippers and carriers, arranging for service, adjusting disputes, and handling matters which otherwise would result in complaints and litigation.

As an illustration of some of its activities, it is at present conducting, in connection with the Department of Agriculture, co-operative tests on lines of different carriers to determine the best method of furnishing protective service to perishable freight. In these tests the Commission and the Department of Agriculture furnish the necessary force of experts, the carriers furnish the equipment and such special facilities as may be needed, and the shippers prepare or load the commodities in accordance with the wishes of those in charge of the tests. The tests consist of actual movement of various perishable commodities from coast to coast in the regular trains equipped with necessary instruments to record temperature and other important details. By such means disputes are adjusted, just and reasonable rules, regulations, and practices established, better protection is given to perishable products, and better service rendered to the public.

The Bureau of Service also conducts quarterly conferences, followed by hearings, in connection with the administration of the act for the safe transportation of explosives, and is in constant contact with the Tank Car Committeee and other committees of this association working out by co-operative means methods of meeting the requirements of the law and improving the service.

In this, as in other matters, the attitude of the carriers is one of helpful co-operation. Prior to the enact-

ment of the car service act car shortages were so common that they they almost became chronic; determined efforts were made by the carriers and the Commission to cope with them by the organization of general committees, but such committees were without authority to enforce their regulations. Immediately following the passage of the act a Bureau of Car Service was organized by the Commission for the express purpose of handling matters relating thereto in co-operation with a similar bureau organized by the American Railway Association. Between those two bureaus the most cordial relations and the most complete co-operation exist. Both are working constantly to provide better service for the public. So long as the railroads with their organization can solve the problems and provide satisfactory service, they handle the matter without interference, as is their duty under the law to do. When problems arise which, because they require modifications of the car service rules, priority in transportation, movement of traffic under permits, or similar matters, cannot be handled by the American Railway Association bureau, our Bureau of Service steps in and under the authority conferred by the law takes charge of the situation and handles it in the interest of the public.

In all matters relating to transportation of explosives joint committees composed of the committee created by this Association, the railroads' Bureau of Explosives, and our Bureau of Service hold regular conferences to devise better and safer methods of handling dangerous commodities. Regulations are amended or changed as conditions require only as the result of such conferences.

Safety

Our Bureau of Locomotive Inspection and Bureau of Safety, in connection with the preparation of rules covering appliances required by the various acts, hold conferences with the carriers and endeavor by agreement to establish proper standards which, when approved by the Commission, are to be observed as meeting the requirements of the law.

Accident investigations are conducted jointly with the representatives of the carriers and the representatives of the State Commissions. When making inspections of equipment, the proper representatives of the various departments of the railroads are invited to accompany the Commission's inspectors so that results may at once be known to the proper official and any improper conditions found may be promptly remedied.

This Association maintains standing committees, which are always available, to meet with the representatives of our bureaus to consider necessary changes in rules or practices to promote safety and meet changed conditions or bring about an improvement.

It is true that in some cases prosecutions are necessary and, as stated by the Commission in its third annual report, when necessary they are instituted, but it has been demonstrated that with a proper spirit of co-operation far more prompt and effective results can be obtained by conference between the appropriate committees representing the different interests and the proper officers of the government. And where the parties to such conferences can discuss the problem before them with open minds, having in view solely the best interests of all, it is rare indeed that a reasonable solution cannot be reached.

I am not unmindful of the fact that in the early days there was very substantial opposition to the regulation of railroads by law and a failure to respond to the efforts of the Commission in the direction of co-operative administration. This was probably due to the thought widely prevalent at that time, and which exists to a limited extent today, that the railroads are private property which should not be regulated by law. That theory, however, is no longer accepted by anyone who has given the subject careful study and is familiar with the decisions of the courts and the results of regulation that have been obtained.

Results

And now a word as to the results. It is not possible on an occasion of this kind to make more than a general statement, but if the results indicate anything it is that since the beginning of railroad regulation the treatment applied has on the whole been sensible, wholesome and constructive. I shall not attempt to quote the figures but they amply support the statement that the results have been greater safety, greater efficiency, better service, better credit, better financial condition of the railroads as a whole, and has given a stability of value to the capital invested in railroads which it never before had.

This association, organized in 1869, has been the pioneer amongst railroad organizations in the development of standardization and co-operation amongst the railroads and between the railroads and the different departments of government charged with the administration of law. There is much in its record of which you may feel justly proud.

Report of the general committee

The membership of the Division at the present time includes 206 railways, representing 398 memberships in the American Railway Association, and, in addition thereto, 211 railroads, associate members of the American Railway Association. These railroads, members and associate members of the American Railway Association, have appointed 1,241 representatives in the Mechanical Division. In addition there are 967 affiliated members and 164 life members in the Division.

Manual of standard and recommended practice

The revision of and additions to the Manual of Standard and Recommended Practice as a result of recommendations of committees at the 1926 annual meeting as approved by letter ballot have been issued in the form of looseleaf pages to be inserted in the Manual.

Interchange rules

The recommendations of the Arbitration Committee and the Committee on Prices for Labor and Materials, approved at the 1926 annual meeting, were incorporated in the Rules of Interchange, some by supplement issued August 1, 1926, and some in a reissue of the rules effective January 1, 1927.

Periodical repacking of journal boxes

The provision in Interchange Rule 66 making the car owner responsible for the cost of periodical repacking of journal boxes approved in the report of the Arbitration Committee at the 1926 Annual Meeting was considered by your committee and the effective date extended to May 1, 1927, in the Interchange Rules issued January 1, 1927. This effective date has since been extended to May 1, 1928, as announced in Circular No. D.V.-505. These extensions have been made to enable car owners to complete attention to their own equipment and also to enable action to be taken with respect to revision of the present recommended practice for packing of journal boxes as will be recommended by the Committee on Lubrication of Cars and Locomotives.

Loading rules

The recommendations from the Committee on Loading Rules, considered at the 1926 Annual Meeting and approved by letter ballot of the members, were incorporated in a reissue of the rules issued, effective January 1, 1927. In addition, upon recommendation from the Committee on Loading Rules, a supplement to the rules was issued, effective May 1, 1927, covering certain modifications. These modifications were all developed with the co-operation of the shippers and were felt to be of sufficient im-

portance to be made effective immediately without awaiting the usual letter ballot action.

Tank car specifications

The tank car specifications containing revisions approved by letter ballot last year have not been reissued for the reason that the Interstate Commerce Commission is issuing specifications covering the tanks of such cars used for transporting dangerous commodities. It was felt advisable to wait until the Interstate Commerce Commission's specifications were issued before issuing the American Railway Association specifications, so there would be no conflict. The Committee on Tank Cars is revising the specifications of the Association to cover tank cars not used for the transportation of dangerous articles and to cover underframe, truck and other car construction details of all tank cars.

Mechanical inspection department

The mechanical inspection department of the division has continued, throughout the year, making investigations covering repairs to foreign cars and billing therefor. Where definite overcharges have been found as a result of these investigations, refunds have been made to the car owners, in accordance with the billing regulations of the Association.

Welding rules

In accordance with authority received from the individual railroads the General Committee has arranged to represent the railroads in negotiations with the Bureau of Locomotive Inspection relative to welding rules.

Joint investigation of tank car appliances and devices

In co-operation with the American Petroleum Institute and the American Railway Car Institute, Mr. D. V. Stroop of the United States Bureau of Standards has been employed for a limited time to conduct tests and investigations of tank car appliances and devices.

The International Railway Association

The following questions have been submitted by the General Committee for discussion at the Meeting of the International Railway Association at Madrid, Spain, in 1930:

1—Future development of locomotives with high boiler pressure, either compound or with limited cut-off.
2—Use of aluminum alloys for passenger cars.
3—High speed electric locomotives.
4—Development of Diesel-electric locomotives.

Rule 112—Settlement for rebuilt cars

The committee in its report last year advised the members of the complaint filed by the Bangor and Aroostook relative to the rules of the association governing the settlement for cars destroyed and of the arrangement made for defending the rules before the Interstate Commerce Commission. This hearing has been held, but no decision has been handed down by the Commission to date.

Elimination of brake pipe angle cocks from passenger equipment cars

The letter ballot recommending the elimination of angle cocks from passenger train cars failed to receive sufficient votes for adoption, the vote being: in favor, 596 votes; against, 440 votes.

The members are urged to make definite tests to convince themselves of the feasibility of this proposition and the matter will be submitted again to letter ballot at a later date.

Limit load stenciling

The rule relative to stenciling freight cars to show load limit apparently is being followed up very rapidly. It is urged, however, that each car owner canvass the situation with a view of completing this stenciling within the time limit.

Study covering the cost of transferring bad order cars

The committee considered jointly with the General Committee of the Transportation Division question of economic loss in transferring bad order cars, and as a result of this joint consideration, there has been submitted to the General Committee of the Operating Division a tentative formula covering the elements of cost involved, with the recommendation that this formula be applied to the transfers at a number of important gateways to develop actual cost of transferring bad order cars when all items of cost are included, and after this application of the formula has been made recommend such changes, if any, which may be necessary to make it a practicable formula.

Investigation of the rules for car hire settlement between carriers, I. C. C. Docket No. 17801

The first hearing in this case was held at Washington, March 8 to 12, 1927, inclusive, and was devoted almost entirely to the presentation of general testimony by the Short Line Association in support of its request for a modification of Per Diem Rule 6 involving settlement between subscribers to the Per Diem Rules Agreement and their non-subscribers connections. Some individual cases were also heard, and most of them involved requests of individual short line railroads to be permitted to make settlement for car hire in accordance with the so-called Birmingham Southern Rules. There was presented by the special committee on behalf of the American Railway Association general testimony in support of the Per Diem Rules.

It is expected that further hearings will be held in various sections of the country, but the time and place of such hearings have not yet been announced by the Interstate Commerce Commission.

Designs for standard cars—location of safety appliances

In designing standard box cars the Committee on Car Construction was confronted with the problem of making a satisfactory application of safety appliances with particular reference to the relation of the side ladder, roof handhold and sill step.

Upon recommendation from that committee, the proposition to change the distance from the center of the truck to the end sill striking face, on house cars, from 5 ft. 0 in. to 5 ft. 6 in. was submitted to letter ballot of the members. This ballot resulted in a large majority vote in favor of this change as follows: in favor, 1,954 votes; against, 622 votes. The Committee on Car Construction has been instructed to retain the 5-ft. dimension, if possible, for open top cars.

Proposed changes in existing tariff regulations covering overloaded freight cars

The question of proposed changes in existing tariff regulations covering overloaded freight cars has been referred to a joint conference of representation of the Traffic, Transportation and Mechanical Divisions.

Postal car matters

The General Committee has appointed the following subcommittee to represent the Division in conferring with the Post Office Department on matters effecting Postal Car Specifications: C. E. Chambers (chairman), Central Railroad of New Jersey; F. H. Hardin, New York Central, and W. F. Kiesel, Jr., Pennsylvania.

Term of chairman

After careful consideration and trial it is felt that the term of chairman of the division should be increased to two years to extend between the month of June of the even years. The chairman to be elected and installed in connection with the conventions held with exhibits. It is therefore recommended that Sections 7(a) and 7(b) of the Rules of Order be amended to read as follows:

Section 7 (a). The officers, except as otherwise provided herein, shall be elected at the regular meeting of the Division held in June of each even year and the election shall not be postponed except by unanimous consent.

Section 7 (b). The chairman and vice-chairman of the Division shall be elected by written or printed ballots each even year, the candidate receiving a majority of the votes cast shall be declared elected and shall hold office for two years or until their successor shall be elected.

Life members

The following have been made life members of the Division during the year:

Date joined	Name	Title and railroad
1907	Dickinson, F. W.	M. C. B., Bessemer & Lake Erie.
1907	Diehr, C. F.	M. M., New York Central.
1907	Harris, C. M.	Vice-Pres., Hagerstown & Frederick.
1907	Henry, W. C. A.	Eng. of Motive Power, Pennsylvania.
1907	James, Chas.	Mech. Supt., Erie.
1907	Lamar, A.	M. M., Pennsylvania.
1905	MacRae, J. A.	(Retired) 901 Summit Av., Minneapolis, Minn.
1907	Mechling, J. E.	Spec. Insp., S. W. Region, Penna.
1907	Mengel, J. L.	M. M., Pennsylvania.
1907	Miller, E. B.	D. M. C. B., Baltimore & Ohio.
1907	Montgomary, H.	S. M. P. & R. S., Rutland.
1907	Oviatt, H. C.	Standard Stoker Co., Inc.
1907	Prendergast, A. P.	Mech. Supt., Texas & Pacific.
1907	Richardson, L. A.	G. S. M. P., C. R. I. & P.
1907	Rockfellow, W. E.	D. G. C. F. (Retired), N. Y. C.

Date joined	Name	Title and railroad
1907	Seddon, C. W.	S. M. P., Duluth, Missabe & Northern.
1907	Selloy, S. H.	G. F. C. D., Boston & Albany.
1907	Shelaberger, J.	M. M., Southern Pacific.
1907	Sitterly, W. H.	G. C. I., Pennsylvania.
1907	Van Brimer, Geo.	Gen. Supt., Colorado & Wyoming.
1907	Wyman, R. L.	M. M., Lehigh & New England.
1912	Wallis, J. T.	Assistant Vice-President, Pennsylvania.

Obituaries

The secretary has been advised of the death of the following members during the year:

Name	Title and railroad	Died
Alquist, P.	M. C. B., D. L. & W.	May 4, 1927
Downing, I. S.	G. M. C. B., C. C. C. & St. L.	Jan. 15, 1927
Mackenzie, J.	2468 Arlington Rd., Cleveland, O.	Mar. 19, 1927
Parks, G. E.	M. E., Michigan Central	May 15, 1927
Umpleby, C. H.	M. M., New York Central	....

Nominating committee

The committee recommends that no ballot be taken this year for members of the Committee on Nominations. The present committee is composed entirely of past presidents of the former Master Car Builders and Master Mechanics Association and past Chairman of the Mechanical Division. It is recommended that the present committee be continued.

The report is signed by L. K. Sillcox (chairman), Chicago, Milwaukee & St. Paul; G. E. Smart, Canadian National; C. E. Chambers, Central Railroad Company of New Jersey; C. F. Giles, Louisville & Nashville; E. B. Hall, Chicago & North Western; A. Kearney, Norfolk & Western; J. E. O'Brien, Seaboard Air Line; John Purcell, Atchison, Topeka & Santa Fe; J. S. Lentz, Lehigh Valley; J. A. Power, Southern Pacific Lines in Texas and Louisiana; O. S. Jackson, Union Pacific; F. H. Hardin, New York Central; A. R. Ayers, New York, Chicago & St. Louis; S. Zwight, Northern Pacific; A. G. Trumbull, Erie, and R. L. Kleine, Pennsylvania.

A motion was carried that the report of the General Committee be approved as a whole.

Report of committee on nominations

The terms of office of the chairman, vice-chairman and seven members of the General Committee expire June, 1927.

Section 7 (a) of the Rules of Order provides that officers of the division shall be elected at the regular meeting of the division held in June of each year. In view of the fact that the General Committee will recommend in its report a modification of this provision of the Rules of Order to provide for extending the term of officers to two years, to expire on the even year, and in order to make this fully effective in June, 1928, your committee nominates the following for the office of chairman and vice-chairman:

For chairman—Term expiring June, 1928: L. K. Sillcox, general superintendent motive power, Chicago, Milwaukee & St. Paul.

For vice-chairman—Term expiring June, 1928: G. E. Smart, chief of car equipment, Canadian National.

As the terms of seven members of the General Committee expire in June, 1927, your committee nominates the folowing to serve until June, 1929, as members of the General Committee: A. R. Ayers, assistant general manager, New York, Chicago & St. Louis; F. H. Hardin, assistant to president, New York Central; O. S. Jackson, superintendent motive power and machinery, Union Pacific; J. S. Lentz, master car builder, Lehigh Valley; J. A. Power, superintendent motive power and machinery, Southern Pacific Lines in Texas & Louisiana; A. G. Trumbull, chief mechanical engineer, Erie, and S. Zwight, general mechanical superintendent, Northern Pacific.

The report is signed by F. W. Brazier (chairman), New York Central; H. T. Bentley, Chicago & North Western; C. E. Chambers, Central Railroad of New Jersey; J. J. Hennessey, Chicago, Milwaukee & St. Paul, and John Purcell, Atchison, Topeka & Santa Fe.

On motion, the report was received.

Officers during past year hold over

In view of the agreement that the officers of the division serve for two years the formal balloting was not held. The officers, as named in the report of the nominating committee were therefore elected on a ballot cast by the secretary.

Banquet on Tuesday evening

A radical departure from the usual program of the Mechanical Division was a banquet on the evening of the first day of the meeting. There was an attendance of about 700. The affair was somewhat similar to the annual dinner of the American Railway Engineering Association at Chicago in March, except that there were a large number of ladies among the guests. The purpose of the banquet was to promote acquaintanceship at the very beginning of the meeting, so that the members could make the best possible use of contacts with representatives from other roads during the remainder of the convention.

G. E. Smart, vice-chairman of the Mechanical Division and chief of car equipment of the Canadian National Railways, was the toastmaster, and short addresses were made by Sir Henry W. Thornton, president and chairman of the board of directors of the Canadian National, and Grant Hall, vice-president of the Canadian Pacific. A considerable number of entertainment features were interspersed throughout the program.

Toastmaster Smart in presenting Sir Henry Thornton, said: "I am going to introduce to you a man that has done the greatest welding job that has ever been done on a railroad. He has fused four distinct railway organizations into one good, harmonious working organization. It has taken him less than five years, and I do not know of any man that today is any better acquainted from the Atlantic to the Pacific. I have great pleasure in calling on Sir Henry Thornton.

Steam locomotive holds its own

Sir Henry Thornton: Those who represent the mechanical Division of the American Railway Association have been engaged for many years in improving that fine, old servant of the North American railway system known as the steam locomotive. Every few years somebody collects a sheaf of flowers and brings them to what is thought to be the funeral of the steam locomotive, but somehow or other it continues doing business at the same old stand in the same old way, and apparently with improved efficiency. It is a matter of congratulation to the mechanical genius of the railway industry that the locomotive has been developed as it is today, and that it is so efficiently playing its part as an instrument of propulsion.

In the early '90s the United States was just springing into its industrial destiny. Great combinations were forming in the steel trade and other industries. Business was forging ahead by leaps and bounds, and that meant that a tremendous traffic burden was placed upon the transportation systems, and unless those transportation systems had succeeded in rising to the emergency the progress of the United States industrially would have been seriously retarded.

What part did the mechanical experts of the railway industry play in making possible that continued development? I say, without fear of contradiction, that it was the introduction at that critical period of heavier and constantly heavier vehicles of greater capacity which permitted the United States to develop as rapidly as it did develop.

The railway industry is confronted by two conditions which work to reduce net earnings—constantly decreasing freight rates, and constantly increasing wages. True, the civil engineer in improved track and permanent way has played his part, but I venture the assertion that the great economy in railway operation which has permitted railway companies in the United States to meet the burden of lowering rates and increased wages has been the

genius, vision and courage of the mechanical engineers.

Tribute to mechanical department

In looking over the last 30 years or so of the railway industry in the United States, the Mechanical Division may congratulate itself upon having largely contributed to the achievement of two objectives: first, the railway companies have handled a constantly increasing traffic successfully and to the satisfaction of the shipping public; and secondly, economy of transportation as a result of mechanical progress has permitted the railway companies to maintain solvency. No finer contribution could be made to any industry than those two objectives which you gentlemen of mechanical science have accomplished.

I think sometimes what you have done is insufficiently known, and it is a pleasure to take advantage of this opportunity to pay a well-merited and well-deserved tribute to the mechanical engineers of the railways.

However important mechanical progress may be; however important improved transportation methods may become; however important any activity of any of the railway departments may be, the whole thing, and all of the efforts of any department is subordinate to one single fundamental fact, which is the genesis of the railway business, and that is getting the traffic.

A well-handled train, a skilful engineman, a polite conductor, a good dining car service, all of these things contribute to getting traffic, and I claim that every officer and every employee of a railway can contribute something in the course of the year either directly or indirectly to attract traffic to the railway.

Your function as mechanical engineers is to provide a constantly improving power, to maintain your power and equipment in a serviceable condition with minimum cost, but back of all that is getting the business. By doing your job successfully and efficiently as mechanical engineers you are not so much helping the mechanical department of your railways as you are helping the traffic department.

Traffic is what counts

I often think we become blinded in the railway business by the suspected importance of our own immediate work. We feel that the department in which we work is fundamentally and primarily essential for the existence of the railway, and that most things in the railway are subordinate to that department. But, after all, it is teamwork, it is co-operation, that gets the traffic, and unless there is traffic to haul there will be no traffic department, no maintenance department, or no other kind of department.

If I might venture to leave any message with you as one who may have had some experience in the railway business of more than one country, I would say this: That however necessary your progress may be, the essential thing is to see to it that you play your share and your part successfully in getting traffic to your railway.

Grant Hall introduced

Toastmaster Smart: The gentleman that I am going to introduce to you now is one whom many of you have met through his associations with the Mechanical Division. He started his railway career as an apprentice in a machine shop, and worked his way successfully through the mechanical department until now he holds the position of vice-president of the Canadian Pacific. That railway extended its lines across the continent 60 years ago. It is celebrating this year its sixtieth anniversary which is also coincident with the sixtieth anniversary of the Confederation of Canada and of the organization of the Master Car Builders' Association.

The Canadian Pacific Railway played a great part in the confederation of Canada. President Beatty is now in western Canada and greatly regrets his inability to be here. I now have great pleasure in calling on Grant Hall, vice-president of the Canadian Pacific.

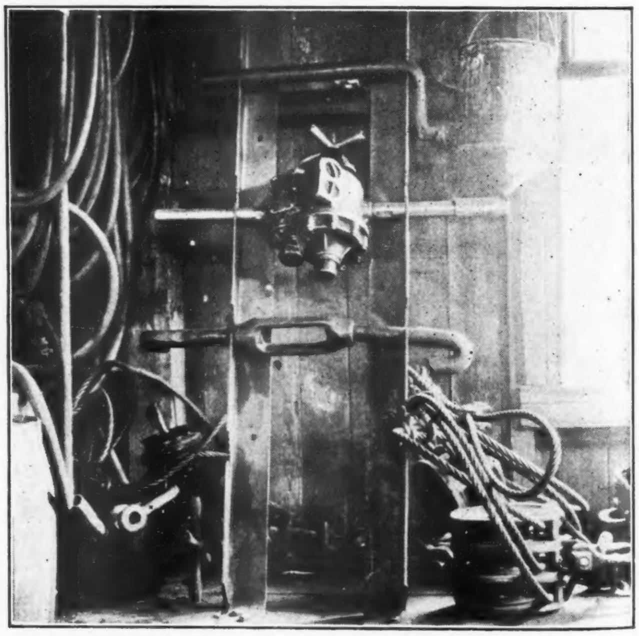
Achievement of mechanical associations

Grant Hall: Let me welcome you to Montreal as an old member of the Master Mechanics' Association. The Master Car Builders' Association was formed about 1865 and reorganized in 1882. The Master Mechanics' Association followed about one or two years later. In 1919 the Master Mechanics' Association and the Master Car Builders' Association joined together and formed what is known now as the Mechanical Division of the A. R. A., and if I remember correctly my very good old friend, who has now gone beyond, William J. Tollerton, was president at that time.

You have a great record behind you in the Master Mechanics' and the Master Car Builders' Associations. The work you have done stands and speaks for itself. One or two outstanding accomplishments include the recommendation and the adoption of the automatic brake and the automatic coupler. But the greatest thing to the credit of the Mechanical Association is the general rules of interchange which have made it possible to handle the present-day traffic conditions.

Storing portable motors in a tool room

AIR and electric portable motors, on account of its shape and weight, are rather hard to stow away in the tool room. They should not be piled on the floor. In the tool room of the D. & R. G. W., Denver, Colo., a convenient rack has been devised for this purpose.



A convenient rack for holding motors

It is made of two 4-in. by 4-in. angles, 8 ft. long, sloping sharply from the floor to the wall, and securely bolted at each end. At short intervals, notches are cut with an acetylene torch to receive the handles of the motors.

Progress of the steam locomotive

Improvements in running gear and boiler design indicate future possibilities—New types of power show operating economies

THE three papers presented by W. H. Winterrowd, vice-president, Lima Locomotive Works, Inc., Dr. W. F. M. Goss, and Lawford H. Fry, metallurgical engineer, Standard Steel Works, respectively, and the report of the Committee on Locomotive Design and Construction, which were presented at the annual meeting of the Mechanical Division of the American Railway Association held at Montreal, Que., June 7 to 10, inclusive, were excellent contributions to the general subject of steam locomotive design and operation. All three of the papers discussed some phase of the twofold development of the steam locomotive; namely, the boiler and the engine. Of these two, the boiler is undoubtedly the most important at the present time, largely because the principles underlying the application of steam have, for a long time, been better understood than those applying to economical generation. Mr. Fry points out that we are today without the basic facts upon which to design with certainty a locomotive boiler to produce most economically the maximum evaporation under varying service demands, with a minimum fuel consumption.

Both Mr. Winterrowd and Mr. Fry illustrated by recent examples of locomotive design that the railroads and builders are favoring a relatively larger grate area than has heretofore been the accepted practice. This has naturally resulted in an increase in firebox volume which Mr. Fry considers to offer the greatest opportunity available for the economic utilization of coal in steam production.

Dr. Goss presented a paper on the subject of locomotive drafting, a phase of locomotive design on which he is an authority, having been directly connected or associated with various research activities on the drafting of locomotives since about 1895. He was dean of the school of engineering and director of the engineering laboratory at Purdue University in 1901, at the time the late G. M. Basford, acting on behalf of the American Engineer and Railroad Journal, of which he was the editor, secured the co-operation of a number of representative motive power officers for the purpose of securing information which would aid in the logical design of an efficient drafting apparatus.

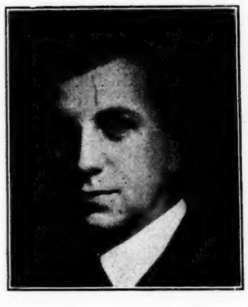
Dr. Goss's present preference to work on an application of an exhaust fan, directly connected with a steam turbine energized by the exhaust steam from the locomotive cylinders, is of particular interest because exhaust fans, as they have been tried on locomotives in the past, have always failed. He has approached the subject from the standpoint of scientific inquiry which has freed him, as he says, from many conservative restraints that have been set up by tradition.

The detail work of the Committee on Locomotive Design and Construction this year is devoted to the standardization of driving, engine truck and trailer axles of steam locomotives and to a study of frame attachments for boilers. The committee also discusses the relative merits of the three- and two-cylinder arrangements, and the possibilities of high boiler pressures.

Locomotive development and cost of operation*

By W. H. Winterrowd

Vice-president, Lima Locomotive Works, Inc.



W. H. Winterrowd

Any consideration of the relationship of the modern locomotive to the volume of business handled and to the direct cost of operation of our railways takes on added significance if prefaced by a brief study of operating statistics. This study develops a number of important facts. It shows that during the past twenty years, with but a slight increase in main trackage, the railways have handled a vastly increased volume of business. Of outstanding significance is the fact that trains steadily increased in weight and moved faster. In other words, the railroads produced more gross ton miles per train hour, an increase which in 1925 amounted to 123 per cent over 1906, and 57½ per cent over 1916.

This remarkable increase in gross ton miles per train hour or power output is due to a number of factors among which may be mentioned grade reduction, improved signalling, improved terminal facilities, larger cars and larger locomotives. The locomotive has played the most important part in this increase. Year by year it has grown in size and capacity. With each increase, heavier trains resulted. This growth in size of motive power continued until a few years ago when property restrictions made further increase impractical.

This, however, was no bar to increased power and economy and locomotives were designed and built that since then have set the pace for still further and more intensive railroad operation. These locomotives without increased weight on driving wheels are capable of greatly increased power output with a remarkable increase in economy of operation.

The table which follows shows the remarkable progress in locomotive development that has taken place since 1921. Here we will see the large increase in horse power output, or the ability to produce more gross ton miles per train hour. The steady increase is impressive, particularly so when we note the greatly increased fuel economy that has accompanied it.

Increase in horsepower and decrease in unit fuel consumption, 1921 to 1925

	Cylinder hp.	Lb. coal per d.b.hp. hr.
1921 Mikado	2,300	5.66
1922 modern Mikado	2,766	4.44
A-1—1925	3,675	2.98
Per cent change, 1921 to 1925	59.5 inc.	47.5 dec.

*Mr. Winterrowd's paper was illustrated with moving pictures and lantern slides. Such information from the pictures as is essential to an understanding of the text has been included in notes of tables.—Editor.

Influence of low combustion rates and cylinder economy in fuel consumption

	Equal horsepower			Equal coal consumption		
	Hp.	Lb. steam per hour	Lb. dry coal per hour	Coal per hour	Lb. steam per hour	Hp.
A-1	1,600	40,500	4,750	6,000	48,000	2,028
1922 modern Mikado	1,600	47,500	7,100	6,000	42,600	1,352

Railroad men and locomotive builders have approached the problem of increasing the usefulness and efficiency of the locomotive from different angles, but all are aiming at the same results—the production of maximum power with the lowest cost of operation. Certain fundamentals of design are now in use by all the builders. These are: high boiler capacity with low combustion rates; high cylinder capacity and economy in use of steam, and refinement of design to increase power capacity and decrease the cost of maintenance.

High boiler capacity with low combustion rates demands a boiler with a large firebox and a large grate area. The first recognition of the value of this combination was evidenced years ago when the narrow firebox between the frames was superseded by the so-called wide firebox. Locomotives continued to grow in size bringing about ever increasing demands upon the boiler and firebox. To meet this growth and provide the necessary boiler capacity, the firebox and grate area were again enlarged. This increase was made possible by the introduction of the two wheel trailer truck to carry the additional weight.

Railroad operation continued to demand more and more power from the locomotive. A point was reached a few years ago when it became impossible to further increase axle loads in order to provide the necessary boiler capacity. Locomotives were being built with grate areas as large as weight limits would allow but these were already being worked at such high rates of combustion, and at the expense of economy, that the limit to further power increase was definitely located in the firebox. The solution of the problem was to again increase the size of the firebox and grate area. Such a locomotive was built with the increased weight carried on an additional trailer axle. This resulted in the four wheel trailer truck.

When the limits of the four wheel trailer truck, firebox and grate area are eventually reached, as they will be, by ever increasing demands of operation or by the requirements of burning low grade fuels, the next step may be a still larger firebox and grate area, the weight of which may be carried by a six wheel trailer truck.

At the present time, there are nearly three hundred locomotives in service or on order, in both freight and passenger service, that are equipped with large fireboxes, the weight of which is carried by four wheel trailer trucks.

[Moving pictures were introduced here to illustrate how low combustion rates produce economical boiler performance, and how large grate area increases boiler capacity, keeping the road working range well within the economical range of boiler efficiency. The pictures showed that for the ordinary Mikado, the normal range of operation includes the sharp drop in efficiency near the point of maximum capacity of the boiler.—Editor].

To produce higher drawbar horsepower output, recent designs of locomotives all take advantage of using steam more expansively coupled with high boiler pressure. Several methods of obtaining this objective include: two-cylinder limited cutoff arrangement with high boiler pressure; three-cylinder simple arrangement, in which limited cutoff is sometimes used; three-cylinder compound arrangement with high boiler pressure, and two-cylinder compound arrangement with high boiler pressure.

The first method, now represented by 145 locomotives in service or building, is to increase the cylinder power by limiting the cutoff and raising the boiler pressure. This has the effect of slightly increasing tractive force at starting and the advantage of raising the drawbar horsepower at operating speeds in proportion to the increase in pressure.

[Moving pictures were here introduced to show how limited cut-off and high boiler pressure accomplish this power increase, without increased weight on drivers, and how marked steam economy is also effected.—EDITOR.]

It follows that if less steam is required to produce a given amount of work, there will be a reduced demand upon the boiler. The boiler with the large grate area can produce steam more economically than one with a small grate. We thus have the combination of reduced demand upon the boiler and increased efficiency of combustion. Just what this combination means in fuel economy is shown the table.

The use of limited cut off and high boiler pressure results in increased power, which means increased piston thrusts in a cylinder of given size. The distribution of these thrusts within limits that insure nominal stress and cool running pins was solved by what is known as the articulated or extended main rod. This type of rod is now in use on about 200 engines in service or building. This design has the advantage of distributing the piston thrust over two of axles and two pairs of boxes and pins instead of one. The A-1 locomotive has made approximately 85,000 miles in the hardest and most exacting kind of service on a number of railroads. The original brasses are still in her driving boxes. Recent examination indicates the brasses are still in splendid condition and the locomotive is continuing her service with these brasses in place.

One road using the extended type of main rod reports a piston thrust of 165,000 lb. and an average life of 24,000 miles per set of bushings as against 15,000 miles per set on a standard locomotive having the ordinary rod arrangement and a piston thrust of only 123,000 lb. It is easy to see what this means in reduced cost of maintenance.

The use of cast steel cylinders illustrates how reduction in weight makes possible increased boiler capacity. Cast steel cylinders applied to the A-1 locomotive permitted a saving in weight of 4,000 lb. This weight when put back into the boiler produced additional capacity. Cast steel cylinders have the additional advantage of greatly simplifying and reducing the cost of repairs. Should a cylinder become damaged, it is a simple matter to weld cast steel.

There are a number of other factors which make for marked reduction in maintenance and therefore are a factor in reduced operating costs. Automatic wedges insure proper wedge height continuously. This reduces rod, pin and driving box maintenance. Articulated four wheel trailer trucks permit maximum capacity ash pans. This eliminates the necessity of stopping trains to clean pan or reduces the time at water stops where pans would ordinarily be cleaned. The articulated four-wheel trailer truck also has the advantage of transmitting the drawbar pull of the engine closer to the center line of the track. This makes for additional capacity and also reduces the wear on driving wheel tires. Superheater cover boxes permit access to the superheater and smoke box throttle without the expense of opening up and tearing out smoke box plates and netting. Smoke box throttles afford closer control of the engine, which reduces slipping. This results in decreased driving tire wear. Dome shut-off valves make possible repairs to steam pipes and throttles without blowing down the boiler. Large capacity tanks decrease stops for water and permit passing water plugs where water is bad. This reduces the cost of boiler maintenance. Large boilers produce steam without forcing. Maintenance is always less in boilers that are not forced and which are worked in a normal range.

Air compressors located on the front end and accessible from the engine house floor facilitate inspection and insure easier and better maintenance. Piping of all kinds simplified and properly braced. It is also located where it is accessible with minimum labor and expense.

In addition, there are a number of other factors that make for increased capacity and economy. Their use has been so well established that in a presentation of this kind, a mere enumeration of them is sufficient. These include Type E superheaters, feedwater heaters, superheated steam for auxiliaries, siphons arches and long valve travel.

Relation to cost of operation

Locomotives built along the lines illustrated in the preceding scenes have been in operation long enough to show how they will affect operating costs.

One railroad reports a number of modern two-cylinder switch engines in service with high boiler pressure, limited cutoff, feed water heaters, and a tender booster. This road states that not only do these locomotives produce more power and make possible the handling of a greatly increased number of cars but do it with so much economy that the saving in fuel alone will pay for the first cost of the engines in seven years. Is power like that a good investment?

Another road with highly modern switch engines has made a careful study of the cost of operation and states that the modern power has decreased the cost of handling cars 19½ per cent. This includes wages, fuel, locomotive repairs, and engine house expense. Due to improved design, material and workmanship, the maintenance costs on the basis of cars handled have been decreased 40 per cent. Fuel consumption has been decreased 37½ per cent. These savings brought about by the introduction of these modern locomotives have resulted in earnings at the rate of 58.7 per cent on the investment. Is such motive power a good investment? Would you hesitate long to invest money that would safely bring such a return?

Relation of modern freight power to cost of operation

For a given amount of work on a division 100 miles long

Annual traffic = 2,435,000,000 gross ton-miles

Traffic per day = 82,200 gross tons

	Super power locomotives	Old locomotives
Average train load	1,533	1,148
Trains per day	53.6	71.6
Train miles per day	4,350	5,810
Locomotive miles per locomotive day	4,710	6,450
Number of locomotives daily	42	59
Cost of operation	$2,342,470	$3,107,060
Gross saving	$764,590	....

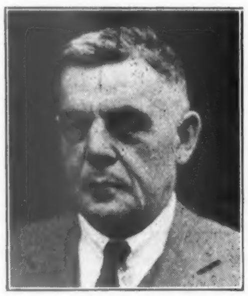
In order to give you a picture of what the modern super-power locomotive will do and how it is related to the cost of operation, a detailed study was made upon a particular road, where quite a number of such locomotives are in regular service. I call attention to the fact of many engines in regular service so that the results will not be confused with the performance of any particular individual test.

This data, which is summarized in the table, is the result of intensive study of the railroad's operating figures over a period of three months and covers all factors of freight train operating results and their costs. Comparisons are all made on the basis of actual performance. They show that increased power output and increased economy result in greatly decreased operating costs. The train load increased 33 per cent, the average train speed 7.4 per cent and fuel consumption decreased 18.5 per cent. The cost of maintenance decreased 35.2 per cent, and operating expenses per 1,000 gross ton-miles were cut 25 per cent. In this particular case a saving of $764,598 per year is being accomplished. This is six per cent on over $12,700,000, which principal amount would buy almost three times the number of locomotives that are required to do the work. If transportation is the life blood of this nation, modern steam locomotives are the red corpuscles of that stream.

Improving the locomotive boiler by research

By Lawford H. Fry

Metallurgical engineer, Standard Steel Works Company



Lawford H. Fry

The Mechanical Division has as one of its main purposes co-operative study and research directed to the betterment of railroad motive power. The paper is, therefore, planned to show how research can be directed to extending existing knowledge of the locomotive boiler. With this in view the fundamental processes of combustion and heat transfer are surveyed. The boundaries of existing knowledge are mapped out and indications given as to how these boundaries may be enlarged and the benefits that might be expected.

When the total heat energy of the steam produced is compared with the heat in the fuel fired, the overall boiler efficiency is measured. Study of locomotive boiler efficiency dates back to the earliest days of the locomotive. Pambour in 1834 reported tests showing that each pound of coke fired evaporated from five to seven pounds of water. Soon after this it was recognized that the amount of steam produced per pound of fuel—that is boiler efficiency—depended on the rate of firing, the efficiency falling off as the rate of firing was increased. A number of tests on this subject are recorded in the earlier literature, but our more accurate knowledge of the effect of rate of firing begins with the publication of Dr. Goss' experiments made on the first locomotive testing plant at Purdue University. The general relation between overall boiler efficiency and rate of operation was shown, but the information was still not sufficiently detailed to permit the separation of heat production and heat absorption, which are the components of the over-all efficiency. This more detailed study first became possible in 1904 when results from the Pennsylvania locomotive testing plant at the St. Louis Exposition were published. Since then tests made by Dr. Goss on the rebuilt Purdue locomotive, a few tests made at the University of Illinois, and the extensive series of tests made by the Pennsylvania Railroad at Altoona provide information which throws much light on locomotive boiler performance. From these tests it is possible to draw up complete heat balances for each locomotive boiler tested. Typical balances at various rates of operation are given in Table I as a matter of illustration. These balances separate the heat in the coal fired into five items:

1—Heat utilized in producing and superheating steam. This measures the over-all boiler efficiency.
2—Heat lost from the boiler by external radiation. This and the first item make up the total amount of heat taken up by the boiler heating surfaces.
3—Heat lost in the sensible heat in the smokebox gases. This with the first two items makes up the total heat produced by combustion.
4—Heat lost by the production of carbon monoxide, CO.
5—Heat lost by the escape of unburnt fuel. The last two items together make up the amount of heat lost by reason of imperfect combustion.

In addition to the five items of the heat balance as above, Table I contains two further columns giving respectively the efficiency of combustion and the efficiency of heat absorption. These are discussed below, combustion being considered first.

Combustion

The efficiency of combustion will be determined by the amount of combustible, including CO, which escapes from the firebox without having combined with oxygen, and this will depend on the mechanical conditions under which the fuel and

Table I—Heat balances and efficiencies of combustion and heat absorption

		Heat balance						
			Heat lost				Efficiencies	
Test No.	Dry coal fired per sq. ft. of grate per hour, lb.	Heat utilized in producing steam, per cent	By external radiation, per cent	By heat in the smoke box gases, per cent	By producing CO, per cent	By escape of unburnt fuel, per cent	Of combustion, per cent	Of heat absorption, per cent
6703	18.9	78	3.9	13.5	0	4.6	95.4	85.0
6701	21.5	67	3.4	....	....	....	....	....
6702	22.3	67	3.4	12.6	0	17.0	83.0	85.0
6704	27.0	70	3.5	12.5	2.23	11.7	86.1	85.4
6705	32.3	69	3.5	13.7	1.61	12.2	86.2	83.0
6706	38.2	69	3.5	13.8	1.16	12.5	86.3	83.0
6709	39.3	68	3.4	13.1	.73	14.8	84.5	84.5
6707	49.7	64	3.2	13.8	1.50	17.5	81.0	83.0
6710	50.4	65	3.3	....	....	....	....	....
6715	58.7	65	3.3	12.8	2.04	16.9	81.0	84.3
6708	61.5	63	3.2	13.4	1.68	18.7	79.6	83.2
6711	66.4	60	3.0	11.6	1.59	23.8	74.6	84.5
6716	83.8	61	3.1	13.4	1.67	20.8	77.5	82.6
6712	85.0	59	3.0	11.8	2.00	24.2	73.8	84.0
6717	109.0	59	3.0	13.9	1.64	22.5	75.9	81.8
6713	110.2	56	2.8	12.1	1.45	27.6	70.9	83.2
6714	139.2	53	2.7	11.8	1.04	30.7	67.5	82.5
6721	141.1	53	2.7	12.3	1.94	30.1	68.0	82.0
6723	142.5	53	2.7	....	....	....	....	....
6722	163.3	49	2.5	11.8	1.58	35.1	63.3	81.5
6718	177.0	47	2.4	11.1	1.90	37.6	60.5	81.7
6719	201.3	43	2.2	10.2	1.75	42.8	55.4	81.5
6720	210.6	42	2.1	9.8	2.51	43.6	53.9	82.0

the air enter and pass through the firebox. In the case of coal fuel, for which exact numerical information is most abundant, and which is therefore used as a basis of discussion in what follows, it is found that at low rates of combustion from five to ten per cent of the fuel and about 25 per cent of the oxygen will escape from the firebox uncombined. At high rates of

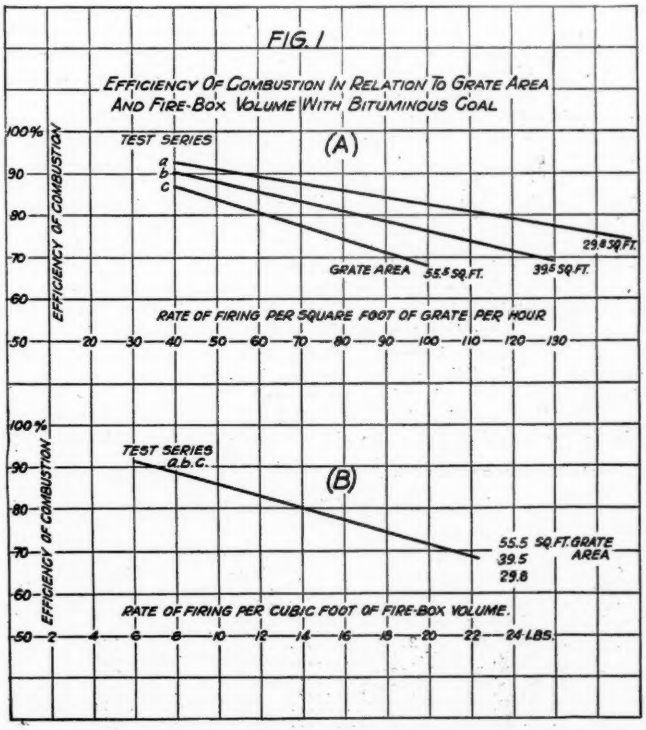


Fig. 1—Efficiency of combustion in relation to grate area and firebox volume with bituminous coal

combustion the percentages will be reversed and approximately 20 to 25 per cent of the coal and about 10 per cent of the oxygen fail to combine. The loss by production of CO usually

appears only at high rates of operation and even then is generally not more than one or two per cent.

When efficiency of combustion is measured by the heat produced expressed as a percentage of the heat in the coal fired, it is found that in all cases the efficiency falls off as the rate of combustion is increased.

This drop in efficiency of combustion as the boiler is forced to higher rates of operation is largely due to mechanical conditions which prevent the carbon and the oxygen from coming into contact and remaining in contact under circumstances favorable to their combination. A certain length of time is required for carbon in the solid state, to combine with oxygen, and therefore a certain duration of contact is essential for complete combustion.

This necessity for prolonged contact between carbon and oxygen is one of the factors which makes firebox volume of importance. Combustion in a locomotive firebox at a high rate of operation is by no means confined to the grate. Part of the primary processes of combustion take place on the grate, the larger lumps of coal are heated there and volatile matter is driven off, but above the grate the whole firebox volume is filled with flame in which combustion is taking place. The volatile gases and much of the finer coal are burned in suspension between the grate and the flues, so that the larger the firebox volume and the longer the flame-way, the better is the opportunity for combination between the oxygen and the carbon.

The firebrick arch is of value in promoting efficiency of combustion because it maintains temperature and increases the length of the flame-way. In stationary boiler practice recent installations provide greatly increased firebox volumes, and rates of operation are commonly measured in terms of coal fired per cubic foot of firebox volume. In locomotive boiler practice the use of combustion chambers is a practical recognition of the value of firebox volume, but in comparing rates of firing it is almost universal practice to do so in terms of coal per square foot of grate area per hour. The evidence on the subject is not entirely conclusive, but leads to the belief that with high volatile bituminous coal, firebox volume is of more importance than grate area in determining the efficiency of combustion; but that with semi-bituminous or hard coal the grate area must be taken into account and must be made sufficiently large to avoid an unduly high intensity of draft through the grate. Further investigation of the value of firebox volume in locomotive boiler design is highly desirable. The test results plotted in Fig. 1 show that with high volatile coal as fuel the grate area in a given boiler can be changed materially without affecting the capacity or efficiency of the boiler. Three series of tests were run with the same boiler, the grate area being different in each series. In Fig. 1-A the efficiency of combustion is plotted against the coal fired per sq. ft. of grate per hr. and three lines result, one for each series. It is evident that the amount of coal fired per sq. ft. of grate does not by itself determine the efficiency of combustion. In Fig. 1-B the same results are plotted, but here the efficiency of combustion is plotted against the amount of coal per cu. ft. of firebox volume. On this basis the results from all three series fall on a single line, showing that with this boiler and this fuel a given amount of coal per cu. ft. of firebox volume produces the same efficiency of combustion no matter whether the grate area be 29.6 sq. ft. or 55.5 sq. ft. Additional, though not quite such striking, evidence of the importance of firebox volume is given by the test results exhibited in Table II and Fig. 2. Table II gives the equations connecting the efficiency of combustion and the coal fired per sq. ft. of grate. These are derived from tests with a number of different locomotive boilers of various designs burning Pennsylvania bituminous coal. These equations give a straight line relation between efficiency and rate of firing and the corresponding lines are drawn in Fig. 2-A with the firing measured in coal per sq. ft. of grate. In Fig. 2-B the lines for the same tests are shown transformed to measure the firing rate in coal per cu. ft. of firebox volume. This latter method of plotting is seen to give less divergence among the lines. Evidence is thus obtained tending to confirm the view that for a locomotive boiler burning bituminous coal the firebox volume is preferable to the grate area as a measure of the capacity for combustion. Further experimental study of the question may be expected to give information of value in enabling locomotive boiler design to be still further improved.

Absorption of heat by radiation

Of the heat produced by combustion a part is taken up by the boiler heating surfaces and the remainder escapes as sensible heat in the smokebox gases. The heat absorbed is transferred to the heating surfaces in two ways, by direct radiation and by convection from the hot gases of combustion. Transfer by radiation takes place mainly in the firebox, and probably transfer in the firebox is mainly that by radiation. The amount of heat transferred in any given case by direct radiation can be estimated if the amount of heat produced, the weight of gases of combustion and the firebox temperature are known. From the weight and temperature of the gases the amount of heat carried out of the firebox can be determined, and this will be found to be considerably less than the heat produced. The difference must be the heat radiated direct to the firebox surface and therefore not available for raising the temperature of

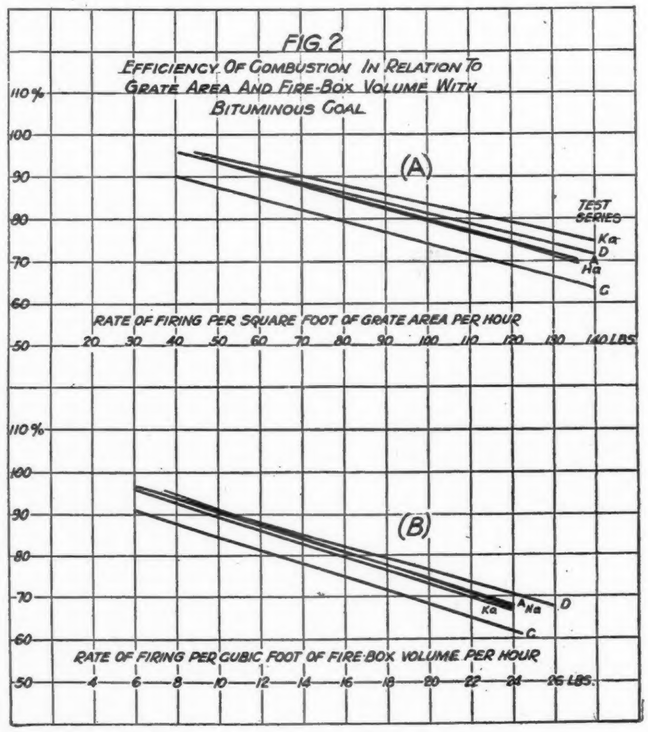


Fig. 2—Additional tests plotted from the results tabulated in Table II

Table II.—Efficiency of combustion in relation to rate of firing

Code for test series	Locomotive	Grate area, R, sq. ft.	Fire box volume, V, cu. ft.	$\frac{V}{R}$	Efficiency of combustion in relation to firing per sq. ft. of grate, Fc = c — dG* c	d	Efficiency of combustion in relation to firing per cu. ft. of firebox volume, Fc = c — d1Gv* c	d1
Ab	Schenectady No. 2	17.0	106	6.3	106	0.258	106	1.62
D	F. R. R. K4s No. 1737	69.3	427	6.1	105	0.237	105	1.45
a	P. R. R. E2a No. 5266	29.8	243	8.2	100	0.170	100	1.39
b	P. R. R. E2a No. 5266	39.5	243	6.2	100	0.235	100	1.39
c	P. R. R. E2a No. 5266	55.5	243	4.4	100	0.316	100	1.39
C	P. R. R. L1s No. 1752	70.0	427	6.1	100	0.263	100	1.60
Ha	P. R. R. I1s No. 4358	70.0	455	6.5	108	0.276	108	1.49
Ka	P. R. R. M1s No. 4700	70.0	494	7.2	105	0.224	105	1.62

*Fc = Efficiency of combustion in per cent.
G = Rate of firing in lb. of dry coal per sq. ft. of grate per hr.
Gv = Rate of firing in lb. of dry coal per cu. ft. of firebox volume per hr.
c, d and d1 are constants for each series of test.
R = Grate area in sq. ft.
V = Firebox volume in cu. ft.
d1=V/R d.

the gases. According to the Stephan-Boltzman law for radiation, if the firebox were completely filled with an incandescent body of gas radiating under ideal conditions, the heat absorbed per square foot of receiving surface per hour would be proportional to the difference between the fourth power of the gas temperature and the fourth power of the temperature of the receiving surface (see Table III). Examination of a number of locomotive boiler tests in the light of this statement leads to the belief that the heat transfer in the firebox is governed by a law of this kind. It seems necessary, however, to introduce a corrective factor to bring into account the fact that at low rates of combustion the incandescent body of gas does not fill the firebox so completely as it does at the higher rates.

Table III

Temp., deg. F.	Heat radiated per sq. ft., B.t.u. per hr.	Temp., deg. F.	Heat radiated per sq. ft., B.t.u. per hr.
1,400	18,200	2,100	67,900
1,450	20,500	2,150	73,400
1,500	22,800	2,200	79,300
1,550	25,300	2,250	85,500
1,600	28,000	2,300	92,000
1,650	30,900	2,350	98,900
1,700	34,000	2,400	106,200
1,750	37,300	2,450	113,900
1,800	40,900	2,500	122,000
1,850	44,700	2,550	130,500
1,900	48,800	2,600	139,500
1,950	53,100	2,650	148,900
2,000	57,800	2,700	158,700
2,050	62,700	2,750	169,100

Heat radiated per square foot of receiving surface at various temperature from formula.

$$\text{Heat radiated} = 1600\left\{\left(\frac{T}{1000}\right)^4 - \left(\frac{t}{1000}\right)^4\right\}$$

T = Temperature of radiating gas in deg. F. absolute.
t = Temperature of receiving surface in deg. F. absolute.
Temperature of receiving surface assumed 391 deg. F. = 850 deg. absolute.

It is believed that further study will give a reliable rule for the rate of transfer of heat in the firebox. This is important as providing a correct method for determining the evaporative value of firebox heating surface. Consideration of the data on which the foregoing conclusions are based indicates that the evaporative value of firebox heating surface depends on the firebox temperature, which in turn depends on the relation between rate of heat production, weight of gases of combustion and area of firebox heating surface.

With a given rate of heat production and a given weight of gases the firebox temperature must be such that the heat radiated at that temperature together with the heat carried by the gases at that temperature is just equal to the heat produced. An increase in firebox heating surface would throw matters out of balance unless the firebox temperature were reduced. The original temperature would maintain the rate of radiation unchanged so that the increase in firebox surface would increase the total heat radiated. Since the amount of gas carried heat, which is dependent on the temperature, would not change, the total heat taken out of the firebox would be increased without an increase in the heat produced which is, of course, impossible. To maintain a balance an increase in firebox surface must be accompanied by a drop in temperature, thus lowering the amount of gas carried heat. The lower temperature will give a lower rate of radiation per sq. ft., so that though the total heat radiated will be greater with the greater surface, the increase in heat radiated will not be in proportion to the increase in firebox surface.

Information available at present allows the foregoing statements to be made with confidence, but knowledge of this important subject is by no means complete and research would undoubtedly produce valuable results.

Transfer of heat by gas convection

The general problem of the transfer of heat by convection from a gas flowing through a flue has been studied by many experimenters. By combining the results of a number of these studies a formula has been developed to give the drop of temperature as the gas passes along the flue. See Table IV. This is a double exponential formula and shows that the temperature drop along the flue depends on the temperatures of gas and of flue, on the flue dimensions and on the rate of gas flow in the flue. It has been used with success to estimate the general condition of heat transfer in locomotive flues and will give a high degree of accuracy if the method of determining or estimating the flue wall temperature is perfected. Fig. 3 and Table IV show the results obtained by using the formula to compute the temperature drop along the boiler flue. The rate of temperature drop is shown for two cases in which the only difference is the rate at which the gas flows through the flue. One case has a rate of gas flow corresponding to what might be expected in a locomotive boiler at the maximum rate of operation, while in the second the rate of gas flow is half that of the first. In passing 20 ft. through the flue the gas temperature, which is assumed to be 2,600 deg. F. on entering the flue in both cases, drop to 625 deg. F. under high power conditions and to 545 deg. F. when the rate of gas flow is halved. This agrees with the usual experience that as the rate of operation is reduced the smokebox temperature is lowered. Translated into terms of heat taken up from the gases of combustion, these temperatures show that the amount of heat given up by each of the 300 lb. of gas flowing at the high rate is about four per cent less than the amount given up by each pound of gas at the low rate. Put the other way round the heat taken from each pound of gas at the high rate is 96 per cent of that taken up at the low rate of gas flow, but as the total weight of the gas is double, the total amount of heat taken up is increased in the proportion of 192 to 100. Doubling the rate of gas flow very nearly doubles the total amount of heat transferred from the gas to the flue. The heating surface of the flue is, of course, the same in both cases. This is an extremely important proposition. Among other things it shows that if half the tubes in a locomotive boiler were plugged and if it were possible to maintain the same total amount of gas flow as before, the doubled rate of flow in the remaining flues would increase the activity of heat transmission to such an extent that the evaporative power of the boiler would be reduced by only about four per cent. It becomes evident therefore that the major factor in determining the evaporative power of the flues is not the area of heating surface they offer, but the amount of gas that can be taken through them. In an actual locomotive boiler working at high power it would not be practicable to plug half the tube and still maintain the same total rate of gas flow. The increase in draft required to move the same amount of gas through half the number of flues would be prohibitive. It is, however, a matter of fairly common experience that a considerable number of flues can be blocked up without reducing the capacity at all proportionately. Applied to the superheater flues, the formulas which have been used to find the curves of Fig. 3 show similar curves, but with a slightly more rapid drop of temperature. This would indicate that the gases emerging from the superheater flues would have a slightly lower temperature than the gases which come through the plain flues. In view of the higher steam temperature in the superheater pipes this is not exactly what might have been expected, but there is some experimental evidence in its support.

Table IV—Heat drop along 2-in. flue by formula

	With 300 lb. of gas flowing through flue per hr.			With 150 lb. of gas flowing through flue per hr.		
Distance along flue, ft.	Gas temperature, deg. F.	Heat carried per lb. of gas, B.t.u.	Heat given up per lb. of gas from entrance of flue, B.t.u.	Gas temperature, deg. F.	Heat carried per lb. of gas, B.t.u.	Heat given up per lb. of gas from entrance of flue, B.t.u.
0	2,600	706	0	2,600	706	0
1	2,305	617	89	2,250	600	106
2	2,060	543	163	1,960	514	192
3	1,850	482	224	1,730	448	258
4	1,670	431	275	1,535	394	312
5	1,520	389	317	1,380	350	356
7	1,280	323	383	1,130	282	424
9	1,100	275	431	960	238	468
11	960	238	468	825	213	493
14	810	199	507	697	170	536
17	700	171	535	608	148	558
20	625	152	554	545	132	574
23	565	137	569	500	121	585
26	525	127	579	470	113	593

The entering temperature is taken as 2,600 deg. F. and the flue wall temperature as 390 deg. F.

The temperature drop is given by the equation: $\text{lolog}\,(T1/t) - Mx = \text{lolog}\,(T2/t)$.

Where "lolog" means logarithm of the logarithm of a number.

T1 is the absolute gas temperature at any point and T2 is the absolute gas temperature at a point x feet along the flue.

M is a coefficient depending on the flue diameter and rate of gas flow in accordance with the following equations:

$\log M = B - m \log W/P$.
$\log (B + 1.3) = 9.71 - 0.54 \log d$.
$\log m = 9.36 + 0.37 \log d$.

Where W is the weight of gas in lb. flowing per hour through the flue.
P is the inside perimeter of the flue in inches.
d is the inside diameter of the flue in inches.

The formulas as at present established are of value in showing how heat transfer by convection is affected by the various factors, rate of gas flow, temperature, diameter and length of flue. To apply them though, at present, it is necessary to make certain assumptions as to the relative distribution of gas between the superheater and the plain flues, and also as to the wall temperature of the flues. Further research to throw

more light on these points would make the formulas of still greater value in analyzing locomotive boiler design.

Before leaving the subject of heat transfer it may be noted that the transfer by convection in the flues is to a certain extent dependent on the transfer by radiation in the firebox. An increase in firebox surface while increasing the heat taken up by radiation reduces the temperature at which the gases enter the flues and therefore reduces the heat available for absorption by convection.

If the total efficiency of heat absorption, that is the total heat taken up by the boiler expressed as a percentage of the heat produced, is studied it is found that in any given boiler the efficiency of heat absorption is only slightly affected by the rate of operation, the variation between minimum and maximum power being usually less than four per cent. Actual values of the efficiency of heat absorption depend on the boiler design, and show a range of from 75 to 85 per cent at maximum power.

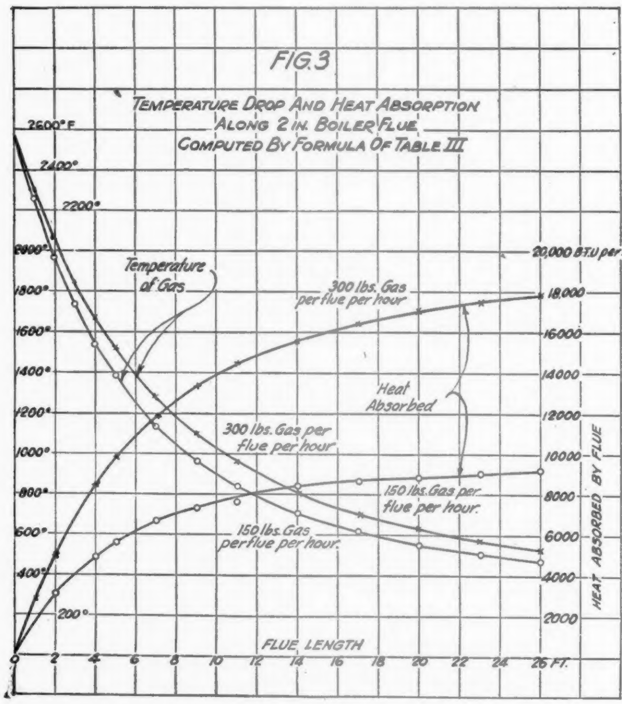


Fig. 3—Chart showing temperature drop and heat absorption along a 2-in. flue

To complete the survey of the boiler in action attention must be given to the conditions under which the air for combustion is supplied. Since George Stephenson's time the locomotive boiler has been distinguished by the use of the exhaust steam from the cylinders to draw the air for combustion through the fire. Though the method has often been criticized as theoretically inefficient its simplicity and practical advantages have maintained it in universal use. In spite, however, of the fact that all locomotives use exhaust steam in a blast pipe to produce draft there is very little organized theoretical knowledge as to the details of this fundamental process. The research carried out in 1896 by Dr. Goss for the Master Mechanics Association could with great profit be brought up to date and further extended to provide a solid scientific basis for front end design.

Summary

As a final word may I quote some remarks I made recently before the American Society of Mechanical Engineers in a discussion of locomotive testing plants:

> A very great step forward could be made if the American Railway Association were to construct or to take over a locomotive testing plant to be devoted to the scientific and impartial study of locomotive designs and devices, and to undertake research work concerned with the basic scientific laws governing locomotive operation. Correct locomotive design is based on definite natural laws, knowledge of which can be obtained only by accurate experiment. The great influence which the locomotive testing plant has had on locomotive design is due to the opportunity it has given for thorough and accurate study of the fundamental laws governing locomotive operation. It is evident that the wider and the more accurate the knowledge a designer has regarding the laws governing the operation of his product, the more confidently and the more successfully can he proceed with improvements in design.

Discussion

C. A. Seley (Locomotive Firebox Company), in discussing Mr. Fry's statements relative to combustion and heat transfer, referred to test data compiled at the locomotive test plant at the University of Illinois. The test referred to included a series of medium firing rates or about 52 lb. per sq. ft. of grate per hour and at higher rates averaging 112 lb., the fuel being run-of-mine, nut, egg, lump and two grades of screenings, thus covering the general conditions by taking the averages of performances. The proportion of the firing rates was more than doubled, being 1 to 2.15, but the average firebox temperatures at the higher rates were only increased about 18 per cent. The speaker said that according to Mr. Fry the additional heat developed at the grate was largely transferred by radiation. He also said that further study of the University of Illinois test data showed that at the high rates, the total evaporation was increased 80 per cent and the total steam temperature 7 per cent, the balance being accounted for in increased stack loss and slight increase of front end temperature. He stated that he did not wish to give the impression that heat transfer is entirely by radiation as the firebox gases, although increased only 18 per cent in temperature, do contribute somewhat by convection to firebox evaporation, and doubling the rate of flow nearly doubles the amount of heat transferred through the flues. Mr. Seley called attention to Mr. Fry's assumption of a firebox temperature of 2,600 deg. F. in Fig. 3, whereas the average firebox temperatures of the Urbana tests were 1887.5 and 2224.3 deg. F., respectively, for the medium and high firing rates, and said that a curve much flatter than that shown would result under these conditions.

H. H. Fanning (A. T. & S. F.) asked Mr. Fry if any consideration had been given to the development of ratios between the grate area and the firebox volume. Mr. Fry replied that he was not arguing for firebox volume as against grate area but was trying to point out that we do not know the relation between firebox volume and grate area and that it was very desirable to have some further accurate experiments which would give us a law for that relation.

There was some discussion relative to the relationship of tube spacing to the efficiency of heat transfer. A. I. Lipetz said that the question of spacing the tubes has been tested and no conclusive results have been obtained, for the reason that the question was not followed up to completion. He advocated more road testing, which, he said, could be conducted in many places under sufficiently constant conditions to add greatly to the limited fund of test plant data.

Developments in locomotive drafting

By W. F. M. Goss
Affiliated Member

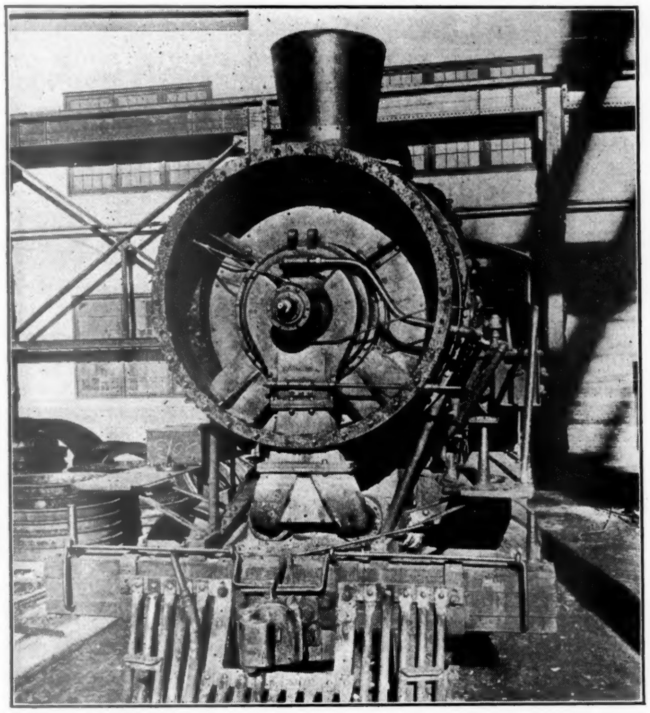
Dr. W. F. M. Goss

(In this paper Dr. Goss presents a comprehensive review of the development of draft and draft appliances used in the modern steam locomotive and forecasts probable future development of a turbo-exhauster shown by service tests to have many important advantages. Following a detailed reference to early attempts at drafting locomotives, the Von Borries-Troske tests, the American Engineer stack tests and the Association's stack tests and paying earnest tribute to the early experimenters in draft production such as Robert Quail, G. M. Basford and H. H. Vaughan, Dr. Goss continues his paper as shown in the following abstract.—Editor.)

It will already have been surmised that the next step in loco-

motive drafting involves the use of a suitably designed and suitably driven exhaust-fan. I have approached my subject with deliberation because I appreciate the reluctance with which locomotive men contemplate such a process. They know it to be a historic fact, that exhaust-fans have been tried on locomotives at various times and in many places, and that they have never been continued in service. It has become a tradition with railroad men that exhaust-fans in locomotive service have always failed. The reasons for their failure, whether the conception was at fault or the design poor, or the materials badly chosen, are rarely sought, and tradition holds its sway.

If, now, instead of relying upon the tenets of traditions, we aproach this subject from the standpoint of scientific inquiry, we are at once freed from many conservative restraints. The problem is one which I have carefully studied. I have been fortunate in having had the co-operation of able interests in the



Turbo-exhauster in place, showing steam connection between exhaust ports and turbo, and blower-pipe connections for road experimentation

development of designs, in the conduct of laboratory experiments, and in tests of an experimentally equipped locomotive on the road; all with the result that much reliable information concerning the possibilities of the exhaust-fan in locomotive service is now available. In fact, speaking from a scientific point of view, mechanical draft in locomotive service is today better understood than was the present front-end with its open exhaust-jet before this Association had undertaken its development, thirty years ago.

Darius Green attempting flight by chance, failed in his purpose, and established a tradition that flight by man was impracticable; the Wright Brothers, guided by scientific procedures, shattered that tradition and attained successful flight. The art of producing draft in locomotive service has now reached a condition of scientific stability. The theory underlying design of exhaust-fans for producing draft, and of steam turbines for driving them is now well understood; our range of choice in the selection of materials from which to construct such equipment has, in recent years, been extended, and men of skill are ready to proceed with the details of design. We never really achieve until we are able to step beyond the limits of present day accomplishments. It is time for the next step. Shall we take it?

The turbo-exhauster

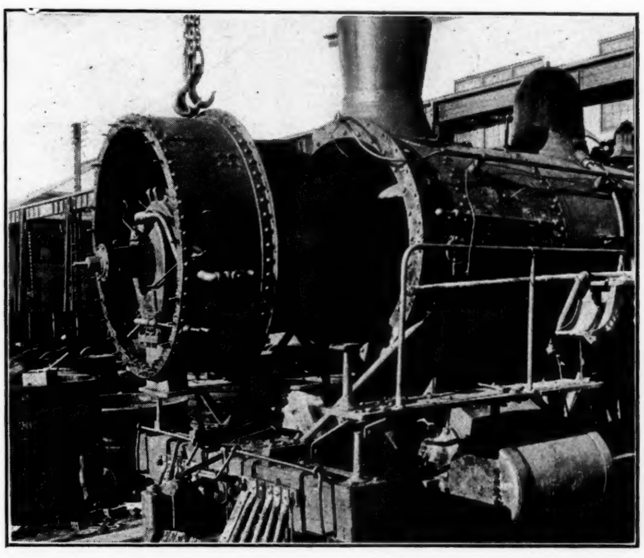
A decision to proceed with the installation of mechanical draft in locomotive service at once opens the way for many different arrangements of details. I have preferred to work on an application of an exhaust-fan, directly connected with a steam turbine energized by the exhaust steam from the locomotive cylinders. The combination of turbine and fan, hereinafter referred to as the "turbo-exhauster," is a self-contained unit having a single shaft carrying a steam-turbine wheel at one end, and an exhaust-fan wheel at the other. The locomotive exhausts directly into the steam-supply header of the turbine, from which it passes through nozzles of appropriate size to the turbine wheel. The turbine takes all the exhaust from the locomotive cylinders, not a part of it. The nozzles of the turbine are the exhaust-tips of the new arrangement. The steam having done its work on the turbine-wheel is discharged into a casing which conveys it along the shaft of the turbo-exhauster to a point close to the back of the fan-wheel, where it flows in a steady stream into the front-end.

The course of the exhaust from the turbine wheel to the front-end is such that it maintains an atmosphere of exhaust steam about the journals and bearing of the turbo-exhauster and at the back of the exhaust-fan wheel. The pressure of this steam is merely the pressure of the front-end, and its temperature can never be higher than the temperature of steam at or below atmospheric pressure. This arrangement entirely disposes of any trouble which might otherwise be anticipated in maintaining journals and journal boxes within the front-end of a locomotive.

The turbo-exhauster has no valves or governors or other elements of control. All steam that the locomotive exhausts goes to the turbine wheel and the energy that it imparts to the turbine wheel is absorbed by the exhaust-fan wheel, so that the draft action induced by the turbo-exhauster responds to the volume of steam exhausted by the locomotive just as does the draft action in the presence of the open exhaust-jet now in use.

The exhaust of air pumps and of other steam auxiliaries is piped into the steam-header of the turbine, where it goes the same course as the exhaust from the locomotive cylinders. Experiments have shown that the exhaust from the air pump alone is quite sufficient to keep the turbo-exhauster in motion when the throttle of the locomotive is closed, so that on the road the turbo-exhauster never stops, though its speed may vary between very wide limits.

Quite independent of the steam-supply casing of the turbine is a small high-pressure steam header covering a nest of high-pressure nozzles arranged to act upon the turbine wheel. The usual blower pipe connects with this high-pressure header. In firing up, the roundhouse steam hose is attached to blower pipe, steam is turned on, and the turbo-exhauster, operating as a high-pressure steam turbine in quietness and efficiency not otherwise



Turbo-exhauster in ring in process of application for experimentation—All parts of the device go with the ring

obtained, begins its work. The blower may be used as needed, not only when the throttle is closed but also on the road, when the throttle is open, and there is need of a real draft booster. The fact that the blower nozzles are independent of the exhaust nozzles permits them to be effective when worked either independently or in combination with the others.

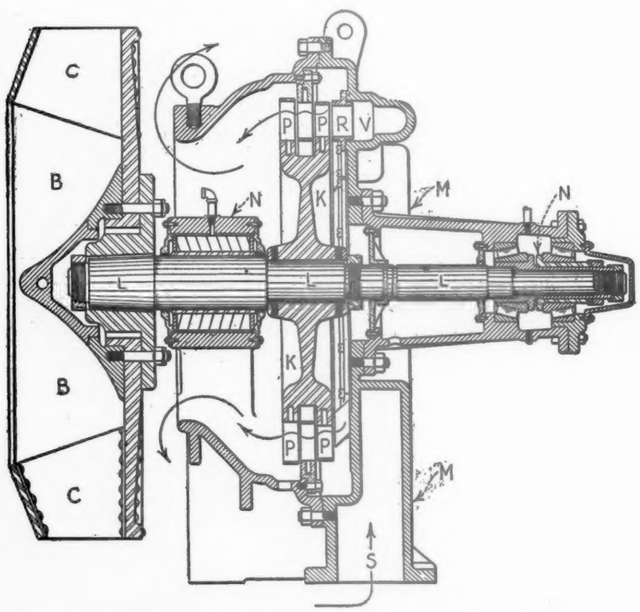
The turbo-exhauster as a whole is arranged in the front-end immediately ahead of the superheater. Its shaft is parallel but not necessarily in line with the center line of boiler. In its application to existing locomotives it will often be found practicable to put it into existing front-ends, but the preferred arrangement is one which provides a short extension front-end ring within which all parts of the turbo-exhauster may be permanently installed. The stack is ordinarily moved forward to the new ring and the old stack-base sealed by a man-hole cover, by the

removal of which, admission is given for inspection of superheater, and related parts. When a full exposure of the front-end is necessary, the supplemental ring carrying out with it all parts of the turbo-exhauster is easily and quickly removed.

The turbo-exhauster presents no difficulties either of design or application arising from scientific considerations. Its fundamental details have all been analyzed and tested. Assuming that the functions it performs are desirable functions, its scientific soundness should insure its ultimate introduction.

The turbo-exhauster as a draft producer

The efficiency of the turbo-exhauster as a producer of draft is the combined efficiency of the steam-turbine and the exhaust-fan. The steam-turbine is a device of comparatively high mechanical efficiency, but the conditions of service in the front-end of a locomotive are variable, and very high efficiency is not to be expected. In my initial study of the matter I assumed an efficiency of 60 per cent for the turbine. The exhaust-fan, with its cinder trap, is necessarily a fan of low efficiency, and I accepted for it an efficiency of 40 per cent. Under these estimates, the combined efficiency is 24 per cent; that is, the turbo-exhauster will return in useful draft effect substantially 25 per cent of the initial energy of the exhaust steam, which is to be



A vertical section of an experimental turbo-exhauster

compared with 8 per cent now obtained from the open exhaust-jet.

If we convert this increase in efficiency into reduction in back-pressure, by reference to a record of performance of the Mikado locomotive tested by Professor E. C. Schmidt, to which reference has already been made, the facts are as follows:

Comparison of turbo-exhauster with normal locomotive

RESULTS OF TESTS—NORMAL LOCOMOTIVE

	Medium power	Heavy power
(a) Lb. of coal per hour	2,900.0	6,600.0
(b) Lb.of steam per hour	23,000.0	42,000.0
(c) Pressure of exhaust, lb	2.0	12.0
(d) Draft, in. of water	2.4	7.0

RESULTS AVAILABLE BY USE OF TURBO-EXHAUSTER

(e) Pressure of exhaust, lb	.85	3.4
(f) Reduction in pressure exhaust, lb	1.15	8.6
(g) Reduction in pressure of exhaust, percentage of Item c	57.0	72.0

These values representing the possible performance of the turbo-exhauster as a draft producer are based upon an assumed performance of the turbine and fan. They have been confirmed in general terms by the performance of experimental equipment in service on the road. It has been shown experimentally that the turbo-exhauster easily supplies all the draft needed, on a back-pressure which is less than half that now employed. Obviously there are great possibilities in this direction, which await the introduction of a more highly perfected design of turbine and fan.

Accepting for the present a reduction of 60 per cent in pressure of exhaust of our present day locomotive, it follows that the turbo-exhauster will save from five to twelve per cent of the steam now used, the precise amount depending upon running conditions. Since, in locomotive service, economy in the use of steam can always be transformed into increase of power, it may be said that the turbo-exhauster, when applied to a modern locomotive, becomes a power booster, to the extent of from 200 to 400 hp.

The turbo-exhauster as a muffler

One effect of the higher efficiency of the turbo-exhauster as compared with the open exhaust-jet now used is a complete elimination of all noise of exhaust. Experience has shown that a two-stage turbine wheel completely silences the exhaust of cylinders and air pumps and the roar of the blower-jet. Regarded merely as a muffler, the turbo-exhauster, unlike most mufflers, does not impede discharge, but actually brings about a reduction of pressure in the energizing steam.

The time has come when the designing engineer cannot be content with any device, however convenient or serviceable, the action of which results in unnecessary noise. The cost of noise in dollars, and in human lives is large, and a modification in design which will permit a steam locomotive to approach the electric locomotive in quietness of operation is in itself worthy of attention.

Effect on spark discharges

The discharge of solids from locomotive stacks has thus far refused to be suppressed. It is not that the solids cannot be separated from the gases, but that when separated, they cannot be gotten out of the front end, which, when the locoomotive is operating, is always below atmospheric pressure. There have been many attempts to provide a side-door for their orderly exits, but they would never use the door; they have always insisted upon passing out through the broad avenue by which everything else finds its exit from the front-end.

In this matter the introduction of the turbo-exhauster brings about a complete change. The solids entrained by the gases are collected in an intercepting ring-collector on the discharge side of the fan, where the fan pressure is maximum, and hence always above the pressure of the atmosphere. All solids thus collected are discharged by a separate pipe, preferably into the fire-box though, if the operator prefers, there is nothing to prevent their being delivered to the ash-pan or upon the road-bed.

This apparently easy disposal of the solids is due entirely to the fact that they are collected in a zone which is always at a higher pressure than that of the atmosphere. All that needs to be done to get them out of mechanism is to provide an outlet through which they may pass.

It is evident that the turbo-exhauster, by returning to the fire-box the solids which now pass out of the stack, is to be credited with such gain in the efficiency and power of the locomotive as a whole as may accrue from such action. Under present conditions of stoker firing, the effect upon output of power is complex, and I have not attempted to analyze it, but its effect upon fuel consumption cannot, I think, be questioned. The tests of fuel in locomotive service to which I have already referred, show that with mine-run coal at medium power, 3 per cent, and at heavy power, 9 per cent, of the heating value of the fuel fire was discharged from the stack. There seems to be no doubt that a device which will return to the firebox the fuels thus discharged will recover these percentages of fuel.

Again the discharge of solids from the stack constitutes one of the serious objections to the presence in congested communities of the modern steam locomotive. The abatement of all such discharges, even if no use is made of their fuel value, represents a very potent advantage to be derived from the use of turbo-exhauster.

Tests of the turbo-exhauster

Steps have been taken to advance the state of the art represented by the turbo-exhauster. The theory of the device has been re-examined, model forms of exhaust-fans and cinder traps have been made and elaborately tested, and a series of full-sized turbo-exhausters have been installed and tested on a locomotive in road service. This work of design and testing, most skillfully conducted, has disclosed:

A complete confirmation of results predicted based on theoretical examination and analysis; that is, the device has done in service what the underlying theory said it would do.

That its use facilitates the process of firing up a locomotive.

That it supplies the requisite draft to make the locomotive steam satisfactorily in ordinary service.

That the back-pressure required to maintain satisfactory draft conditions is not more than half that normally required.

That the exhaust from the air-pump is sufficient to keep the fan turning when the throttle is closed.

That its use supplies the same element of balance between volume of steam delivered by the boiler, and force of draft controlling volume of steam produced, as is given by the open exhaust tip.

That in case of low steam-pressure on the road, the blower nozzle can

be effectively used when the throttle is open, the blower supplementing the exhaust.

That the noise of the exhaust from the cylinders, from the air pump, and from the blower, is eliminated.

That objectionable cloud characteristics of the smoke discharge from the stack are diminished.

That the discharge of solids from the stack is reduced to an amount that is negligible.

It is but fair to add that the service tests developed two sources of difficulty, that the line of solution is in each case apparent but that the solution has not yet been worked out in service. The difficulties and the means by which it will be sought to overcome them are as follows:

The fan wheel suffered severely from the abrasive action of the solids entrained by the gases it was required to handle. The first fan put in service failed after a few hundred locomotive miles; a later fan tested withstood service for five thousand locomotive miles. The service requires a fan-wheel which can be depended upon for at least 25,000 miles. It is proposed to secure such a wheel by progress along three different lines, thus:

1—By making the fan-wheel respond more nearly to smoother stream lines, and to improve the character of material from which the fan-wheel is made.

2—By making certain parts of the fan-wheel heavier.

3—By reducing the work upon the fan-wheel by applying to the intake tube a series of inside spiral fins, so designed as to give the approaching gases, with their burden of entrained solids, a whirl in the direction of the fan-wheel's motion, in order that the blades of the fan-wheel will not alone be required to produce rotary motion in the gases and the entrained solids. As abrasive action diminishes rapidly with reductions in velocity of impact, even slight reductions in this velocity will serve greatly to prolong the life of the fan-wheel.

The efficiency of the turbo diminished under service conditions as a result of the accumulation of oil from the exhaust on its blades. Such accumulation was found to require attention at intervals of approximately 2,000 locomotive miles. It is obvious that the necessity for such attention would be entirely overcome if it should be found possible to introduce an oil separator in the exhaust-pipe connection, and there is a probability that such a solution can be had. In the event that it is not practicable to so separate the oil from the exhaust of the locomotive, it will be entirely practicable to inject into the turbine, at proper intervals, a solvent which can be depended upon to dissolve the encrustation.

The tests having been entered upon for a distinct purpose which did not necessarily involve the complete experimental development of the turbo-exhauster, were terminated when the purpose for which they had been undertaken had been accomplished.

Report on locomotive design and construction

H. T. Bentley
Chairman

Your committee has, during the year, given consideration to the following subjects:

Standardization of fundamental parts of locomotives.

Rail stresses under locomotives.

Use of three-cylinder locomotives versus two-cylinder types.

Provision for expansion of locomotive boilers on the frames; also firebox supports.

Exhaust steam injectors.

Advantages and disadvantages of boiler pressures higher than 200 lb.

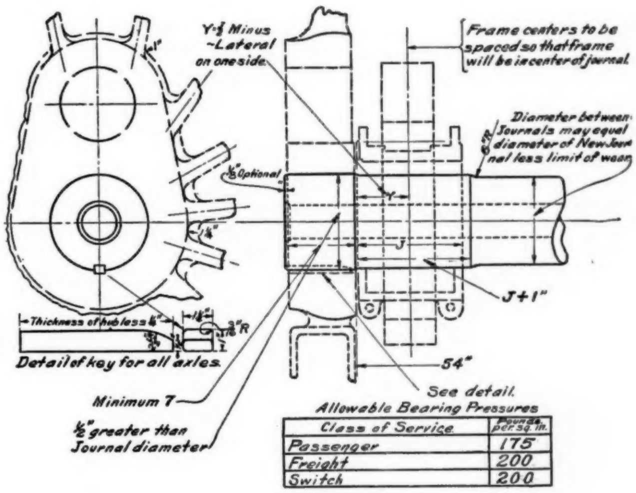
Development and use of oil-electric locomotives.

Standardization of fundamental parts of locomotives

Realizing that the scope of the subject could not be covered in a single year's work, the committee has limited its work this year to the standardization of driving, engine truck and trailer axles of steam locomotives, together with such features of wheel and box construction as are interlocked with the standardization of axles. In its investigation, the committee attempted to gather information from a large number of representative railroads in the United States and Canada, as well as from all the locomotive builders, but was only partially successful. However, the information obtained is sufficient to show that any standardization of fundamental locomotive parts for existing locomotives is practically impossible. The committee has, therefore, proceeded to outline standards which they believe could be consistently followed in the construction of new power. We have also endeavored to limit the number of different axles to the smallest number that can be made to meet all requirements.

The committee feels that it is good engineering practice to design all axles and boxes so that the bearings will be uniformly loaded as a result of piston thrust, as well as weight carried on the axle. The designs recommended therefore show frames and seats for springs and spring saddles located centrally with respect to the bearings.

Information received shows a wide variety of practices with regard to the relative diameters of wheel fits, journals, and centers of axles. The practice of making wheel fits slightly larger than journals, centers, or other adjacent parts of the axle, is almost universal and is recommended because it has proved effective in preventing the origin and development of progressive fractures within the wheel fit, where they are difficult, if not impossible, to detect by inspection. Reduced or tapered center axles are used by some roads for driving and truck axles which have bearings between the wheels. Other roads appear to favor driving and truck axles with straight centers, rough-turned to the same diameter as the journals, for the reason that trouble has been experienced on account of failures occurring in the reduced diameter centers. It is felt by the



Class of Service	Pounds per sq. in.
Passenger	175
Freight	200
Switch	200

Fig. 1—Recommended practices for driving axles

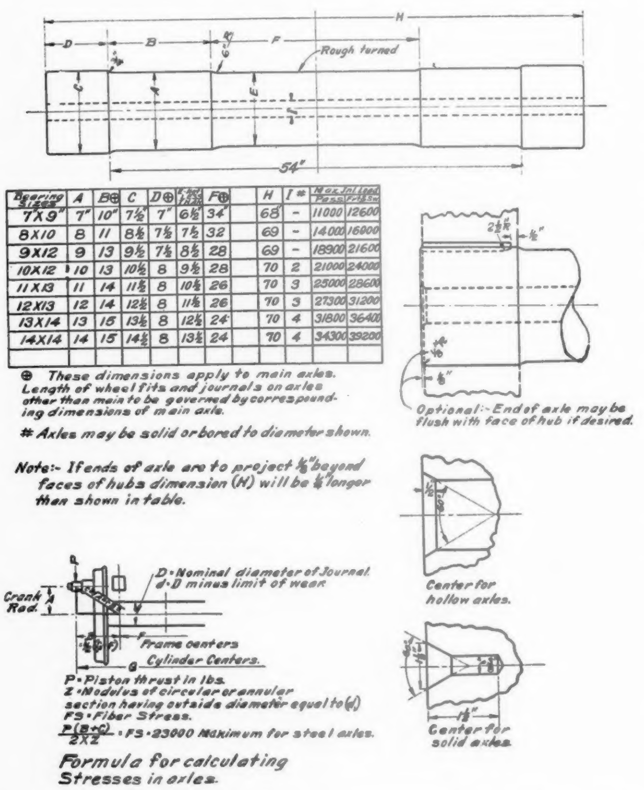
committee that the elimination of all unnecessary offsets or changes in section is an important step in the prevention of progressive fractures. The committee therefore recommends that driving and engine truck axles, having journals located between the wheels, be of the straight-center type except that the diameter of the axle between journals may be reduced to correspond to the nominal diameter of a new journal minus the limit of wear allowed by the road using the axle.

Many roads follow the practice of tapering the centers of trailer axles which have bearings outside the wheels, the tapered centers of these axles being proportioned substantially in accordance with the standard practice for car axles. It is noted, however, that when boosters are applied to trailer axles, the use of the straight center axle is universal and since some of the roads favor the straight-center axle under all conditions, the design submitted shows straight-center axles for all trailer trucks.

The practices of the different roads with regard to the application of collars on the ends of trailer axle journals vary widely, the roads replying being about evenly divided between the collared and collarless axles. The situation with regard to the reduced diameter neck between journals and wheel fit of trailer axles is substantially the same. The committee has therefore made these features optional, as their inclusion or omission is merely a matter of machining. It is noted that most roads find it necessary to control the lateral play of trailer wheels by hub face bearings applied to wheels and boxes. The committee therefore recommends that the journal bearings of trailer axles be formed as close to the hub faces of the wheels as surrounding conditions will permit. This practice has the effect of reducing the spread of trailer truck journal boxes, as well as the fiber stresses in the axles.

Fig. 1 shows the practices recommended by the committee for driving axles. Fig. 2 lists the sizes and dimensions of driving axles that are recommended. Attention is called to the fact that only eight different sizes, advancing by increments of 1 in. from 7 in. to 14 in., inclusive, in diameter, are proposed. It is believed that the sizes listed can be made to satisfy all requirements in designing new power, but the committee has been advised of cases in which roads have been compelled to use axles of certain intermediate sizes in order to avoid exceeding limitation of weight. The committee, in its future work, expects to keep in touch with this phase of the situation, with the idea of recommending additional sizes, if such becomes necessary.

It is recommended that the dimensions of driving axles other than main be governed by the weights carried on the axles and the journal bearing pressures produced thereby. The dimensions of main driving axles should be governed by the fiber stresses produced by piston thrust unless the dimensions thereby arrived at give bearing pressures that are above the limits recommended. In such cases the dimensions of main axles should be governed by the weight carried on them and the bearing pressures resulting therefrom. The standard driving wheel design adopted in 1907, as reflected by page 3, Section F, of the Manual, calls for a standard distance of 55 in. between driving wheel hubs. The work of the committee indicates con-



Bearing Sizes	A	B⊕	C	D⊕	E	F⊕		H	I #	Max. Jnl. Load Pass.	Max. Jnl. Load Frt. & Sw.
7"X9"	7"	10"	7½"	7"	6½"	34"		68"	-	11000	12600
8X10	8	11	8½	7½	7½	32		69	-	14000	16000
9X12	9	13	9½	7½	8½	28		69	-	18900	21600
10X12	10	13	10½	8	9½	28		70	2	21000	24000
11X13	11	14	11½	8	10½	26		70	3	25000	28600
12X13	12	14	12½	8	11½	26		70	3	27300	31200
13X14	13	15	13½	8	12½	24		70	4	31800	36400
14X14	14	15	14½	8	13½	24		70	4	34300	39200

Fig. 2—Sizes and dimensions of recommended driving axles

clusively that this standard hub spacing is not being followed and cannot be consistently followed in the construction of heavy modern power. It is therefore recommended that hubs of driving wheels be spaced 54 in. apart.

Fig. 3 shows the practices recommended for engine truck axles; Fig. 4 lists sizes and dimensions of engine truck axles recommended and Fig. 5 lists the sizes and dimensions of axles recommended for trailer trucks of the two-wheel type.

The report of the sub-committee on Standardization of Fundamental Parts of Locomotives is signed by H. H. Lanning (chairman), A. Kearney, and W. L. Bean.

Rail stresses under locomotives

At the 1924 meeting, an individual paper on Relation of Track Stresses to Locomotive Design, was submitted by C. T. Ripley, chief mechanical engineer, A. T. & S. F. This paper referred to the first tests and surveys on this subject, and also embodied a number of tests conducted on the Santa Fe during 1922, 1923 and 1924, with Mountain type, Pacific type, balanced compound Prairie, and both light and heavy Santa Fe type locomotives. No definite recommendations were made.

At the 1926 meeting, there was submitted a report prepared by a subcommittee of the committee on Locomotive Design and Construction. This consisted of an analysis of the test data reported in 1923 by the A. R. A. and A. R. E. A. special committee on Stresses in Railway Tracks, and by C. T. Ripley at the 1924 session. The committee confined its analysis to steam locomotives of the Pacific, Mountain, Mikado and Santa Fe types.

The report suggested that the distribution of weight be given consideration when designing Mikado, Mountain and Santa Fe type locomotives. No definite recommendations were made which could be formulated to permit of calculating stresses produced in rails under the locomotives due to their mechanical construction.

The subcommittee appointed to make a further study and report at the 1927 meeting, endeavored to secure more recent information of tests that were conducted during 1926, but on account of the test data not being completed, they were unable to embody it in this report.

With reference to information that has been given out by some locomotive builders, relative to low rail stresses produced by three-cylinder locomotives, we have nothing to substantiate this argument, other than the generally accepted principle that a better balance of moving parts reduces speed effects.

After reviewing all available information it is recommended that a joint committee be appointed, comprised of members of the A. R. E. A., who have already made a study of this subject and have accumulated considerable information in connection with it, the A. R. A. committee on Locomotive Design and Construction, and the committee on Electric Rolling Stock. The latter committee has prepared considerable data on the subject with reference to the effect of electric locomotives on rails.

It is further recommended that the A. R. A. give the necessary authority to have additional tests conducted by some well equipped university, such as Purdue or Illinois, which is competent to conduct tests of this character, with the understanding that the above committees co-operate closely with the university selected. Furthermore, if the above recommendations are approved, previous tests and reports should be given consideration, as no doubt the committee will find this information of help in making final report and recommendations.

When conducting these tests, modern locomotives should be used of the types mentioned, and in addition thereto, both the three-cylinder simple and the three-cylinder compound, and also locomotives equipped with 4-wheel trailing trucks. Furthermore, when making this investigation and tests, the different weights of rails and the different methods of ballasting should be considered, as from observation, it would appear that this feature would play a prominent part in arriving at definite conclusions.

The report of the subcommittee on Rail Stresses under Locomotives is signed by W. I. Cantley (chairman), A. H. Fetters, M. F. Cox and H. M. Warden.

Three-cylinder locomotives versus two-cylinder type

It would seem pertinent to give a brief history of the three-cylinder locomotive in the United States, as it dates back at least to 1848. [The introductory historical portion of this report is omitted.—Editor].

In 1922, the American Locomotive Company converted a two-cylinder 4-8-2 type locomotive to a three-cylinder engine for the New York Central. Several radical departures in design were noticeable on this locomotive, the most important of which

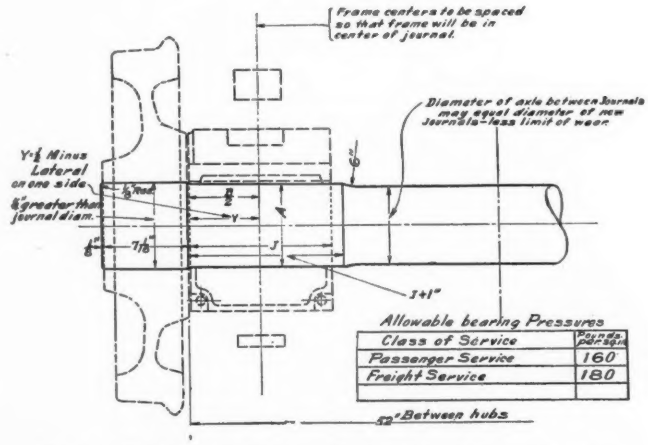


Fig. 3—Recommended practices for engine truck axles

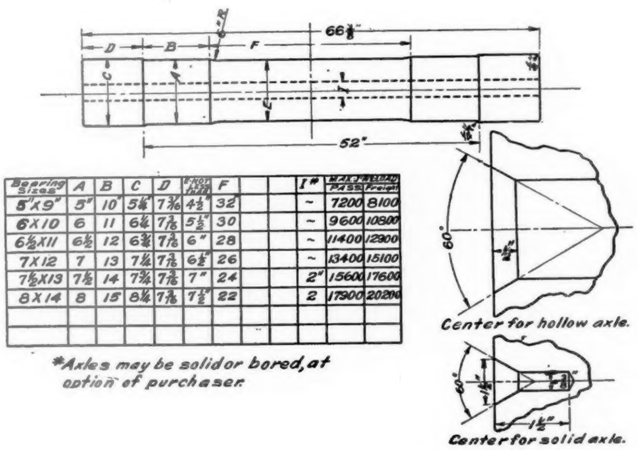
was the use of the Gresley gear developed on the Great Northern Railway in England. The second three-cylinder locomotive, a 4-8-2 type built by the American Locomotive Company, was delivered to the Lehigh Valley in October, 1923. Within a period of two or three months after it was placed in service, a number of test runs were made which showed fuel economy, ability to make up time with heavy trains, freedom from lurching and vibration at high speeds, and ease in starting, it being possible to get a heavy train under way with a noticeable absence of jerking.

Since the installation of these two locomotives, which in a strict sense are the real pioneers of the modern three-cylinder locomotive in this country, there have been, up to the present time, 138 three-cylinder engines built for various roads of the United States. Not the least interesting recent development is

the three-cylinder compound locomotive No. 60,000,* a 4-10-2 type, built by the Baldwin Locomotive Works during the early part of 1926. The locomotive was submitted to extensive tests on the Pennsylvania Railroad's locomotive test plant at Altoona, and is now being tested out in road service on various roads.

There are many more three-cylinder locomotives in service in foreign countries than in this country, Germany being in the lead with approximately 2,000. In England, there are about 250, and 100 distributed among other countries, making a total of about 2,350. A considerable number of these have been in service from 10 to 15 years.

There seems to be no doubt, therefore, that the three-cylinder locomotive has some decided advantages over the two-cylinder design. At the same time, as in most improved mechanical devices, it also carries the usual disadvantages of having an increased number of parts and requiring more care in design and maintenance.



Bearing Sizes	A	B	C	D	E Not less than	F			I*	Max. journal load Pass.	Freight
5"x9"	5"	10"	5 3/4"	7 3/16	4 1/2"	32			~	7200	8100
6x10	6	11	6 1/4	7 3/16	5 1/2"	30			~	9600	10800
6 1/2x11	6 1/2	12	6 3/4	7 3/16	6"	28			~	11400	12900
7x12	7	13	7 1/4	7 3/16	6 1/2"	26			~	13400	15100
7 1/2x13	7 1/2	14	7 3/4	7 3/16	7"	24			2"	15600	17600
8x14	8	15	8 1/4	7 3/16	7 1/2"	22			2	17900	20200

Fig. 4—Sizes and dimensions of recommended engine truck axles

It would appear that improvements made in material and design of the crank axles have overcome the weakness of this detail in the earlier construction, as the modern three-cylinder locomotives have been remarkably free from this defect, only one failure having come to our attention of the 138 locomotives in service in the United States.

For the purpose of collecting data for this report, 24 questionnaires were sent out. Thirteen were sent to roads operating three-cylinder locomotives in this country; three to roads operating three-cylinder locomotives in Europe; and five to prominent roads in this country that have no three-cylinder locomotives in operation, in order to get their views. Replies were received to all our circulars other than those sent to foreign countries, the replies to the latter hardly having had time to reach us. While all of the five roads not operating these locomotives replied, four did not make any comments and one quoted several advantages which rather appealed to them.

The number of three-cylinder locomotives in service on the different roads of this country vary from one to thirty-nine. The types also have a great range, as shown in the following tabulation, which gives the number of locomotives for each type reported, together with their tractive forces and factors of adhesion:

Type	No. of locos.	Tractive force, lb.	Factors of adhesion
0-8-0	11	60,600 to 66,300	4.05 to 3.9
2-8-2	7	65,700 to 67,870	3.7 to 3.74
4-6-2	3	46,400 to 47,100	3.77 to 4.05
4-8-2	51	61,100 to 77,600	3.54 to 4.19
4-10-2	49	78,000 to 84,200	3.7 to 3.77
4-12-2	15	96,650	3.67

This brings out the fact that the three-cylinder principle can be adapted to all standard types commonly used for modern two-cylinder locomotives, and in case of one recently introduced type, the 4-12-2, it is scarcely probable that two outside cylinders would be seriously considered in combination with six pairs of coupled drivers.

These locomotives are in service as follows: Hump yard switching, transfer, freight, fast freight, milk trains, express trains and passenger.

The cylinders range in diameter from 22 in. to 27 in., and are obviously much smaller than would be required to develop the same power if only two cylinders were used. This reduction in cylinder diameter, in addition to reducing stresses set up in machinery and frames, allows reciprocating parts to be much lighter, resulting in less counterbalance in the wheels, and, consequently, in less dynamic augment. Where cranks are set at 120 deg. instead of 90 as on two-cylinder locomotives, there is a further reduction in dynamic augment owing to avoiding the combined effect of two counterbalances acting at one time on either the rail or the locomotive. The result is that stresses set up in roadbed and bridges due to counterbalance are reduced about one-third, thus permitting static wheel loads to be increased by a like amount.

Furthermore, the use of smaller cylinders not only reduces the leverage on main axles and crank pins, thus decreasing the stresses set-up in these parts as well as in frames, wheels and their component parts, but also permits a greater cylinder capacity within the same overall measurement of cylinders.

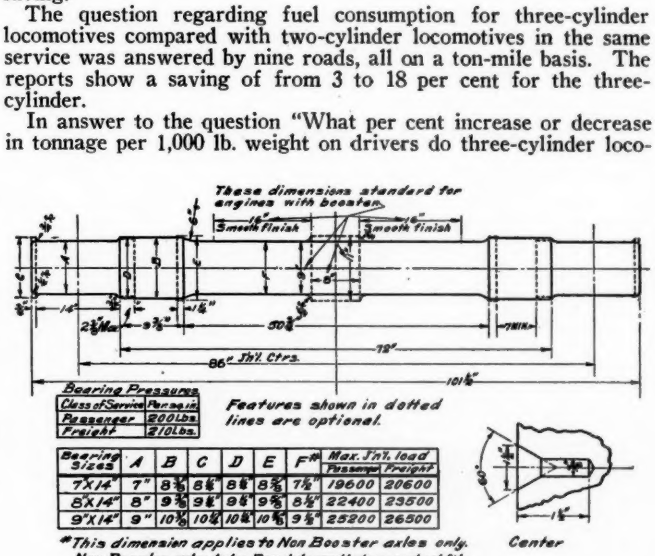
At slow speeds the factors of adhesion of the locomotives reported range from 4.19 to as low as 3.54, all but 17 of the locomotives being less than 4.0. For two-cylinder locomotives the adhesion is nearly always well above 4.0. The low adhesion is made possible only by the use of a third cylinder, which produces a more uniform pulling torque. In any locomotive the adhesive weight must be great enough to prevent slipping with the maximum tractive force developed through a complete revolution of the drivers. The increase of this maximum over the average is much smaller for a locomotive with three cylinders than for one with two cylinders. Hence, for a given weight on drivers, the three-cylinder locomotive can develop from 10 to 15 per cent more rated tractive effort than a two-cylinder design without slipping the wheels.

Restricted cut-off is in use on three-cylinder locomotives in Europe and has been embodied in these locomotives on two roads in this country with satisfactory results.

The questionnaire asked for cost of repairs on a ton-mile basis for three-cylinder locomotives compared with two-cylinder locomotives in the same service. Four roads answered on this basis, three on a mileage basis, and six did not answer. Of those replying on a ton-mile basis, three roads report respective savings of 7.5 per cent, 23.9 per cent and 28 per cent for the three-cylinder, while the fourth states that the repairs are only 25 per cent of that of a two-cylinder engine. On a mileage basis, the figures furnished by one road shows 0.43 per cent increase in cost for the three-cylinder, and by the other road, 21.8 per cent saving.

The question regarding fuel consumption for three-cylinder locomotives compared with two-cylinder locomotives in the same service was answered by nine roads, all on a ton-mile basis. The reports show a saving of from 3 to 18 per cent for the three-cylinder.

In answer to the question "What per cent increase or decrease in tonnage per 1,000 lb. weight on drivers do three-cylinder loco-



Bearing Pressures

Class of Service	Per sq. in.
Passenger	200 Lbs.
Freight	210 Lbs.

Bearing Sizes	A	B	C	D	E	F*	Max. Jn'l. load Passenger	Freight
7"x14"	7"	8 3/8	8 1/4"	8 3/4"	8 5/8	7 1/2"	19600	20600
8"x14"	8"	9 3/8	9 1/4"	9 3/4"	9 5/8"	8 1/2"	22400	23500
9"x14"	9"	10 3/8	10 1/4	10 3/4	10 5/8	9 1/2"	25200	26500

Fig. 5—Sizes and dimensions of recommended trailer truck axles of the two-wheel type

motives haul as compared with two-cylinder type?" all roads except two report an increase of from 3 to 20 per cent. The two exceptions are as follows: One road rates the three-cylinder the same as an equivalent two-cylinder locomotive; another road gives the same rating for both types on a 0.4 per cent ruling grade, but states that on various momentum grades up to 0.9 per cent the three-cylinder locomotive shows as high as 9 per cent increase in tonnage.

Two of the three locomotive builders are building three-cylinder locomotives, both agreeing that these engines have the following advantages over the two-cylinder type:

1—More uniform torque and greater tractive force.
2—A much better balanced condition.
3—A more uniform exhaust pulsation, resulting in better draft conditions, and slight increase in boiling capacity.
4—Lower factor of adhesion.

*For a description of this locomotive, see the Daily Railway Age for June 14, 1926, page 1773.

Roads operating three-cylinder locomotives have also mentioned advantages over the two-cylinder design as follows:

1—Increased tractive force, greater starting power, more rapid acceleration and lower factor of adhesion, due to more uniform torque produced by six power impulses per revolution. For these reasons they are equally advantageous in switching, hump or drag, freight or passenger service.
2—More perfect counterbalance, thus reducing stresses set up in machinery, bearings, boxes, frames, roadbed and bridges, and permitting increase in weight on drivers and greater speed with better riding qualities.
3—Greater cylinder capacity with given clearance limitations and roadbed conditions, and, due to smaller outside cylinders, less leverage and stresses in axles, crankpins, frames, wheels and their component parts.
4—Less slipping, with less tire and rail wear, greater mileage between repairs and between tire turnings, increased gross ton-miles per hour, lower cost of maintenance and operation, and saving of fuel and water on account of three cylinders permitting operating at shorter cutoff for a given power output.
5—Due to the greater number of exhausts per revolution, exhaust nozzle can be opened wider, thus reducing back pressure, causing a milder and more even draft on the fire, and increasing boiler efficiency.
6—Permits dividing application of driving power to two axles instead of one, thus reducing stresses set up and increasing life of parts affected.

The report of the subcommittee on Three-cylinder Locomotive versus Two-cylinder Type is signed by George McCormick, (chairman), S. Zwight and C. E. Brooks.

Provisions for expansion of locomotive boilers on the frames

To support and secure satisfactorily a locomotive boiler on its frame has been of interest since the beginning of locomotive construction; but locomotives built in recent years have, on account of their increase in size and capacity, added some difficulties to the problem of designing supports of sufficient stability and, at the same time, providing for the expansion of the boiler on the frames.

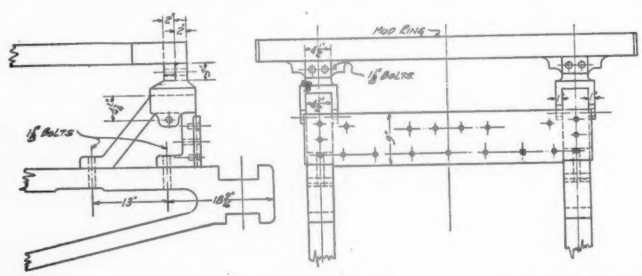


Fig. 6—Back end connection between frame and firebox, design B-3

A large number of drawings have been secured from locomotive builders and many roads, from which some 72 have been selected to show the typical forms developed in the progress of locomotive design, and it is the thought that an assembly of these designs might not only serve as a history of what has been done, but also afford some idea of the trend of thought, experience and opinion as locomotives have grown in size and capacity. In the study of this subject it does not appear to be possible to lay down any definite formulae covering either general or detail construction.

These designs have been divided into groups, as follows:

1.—In the group of drawings designated as "G," and numbered to show the consecutive time of their introduction in locomotive construction, will be found designs of support located near the cylinder, and which for convenience are referred to as "guide braces."

2.—In group "W," will be found designs showing waist sheets, which are the connections back of the guide yoke or back of the cross bar supporting the valve gear.

3.—In group "F," is shown the connection between the frame and the front end of the firebox.

4.—In group "B," is shown the connection between the frame and the firebox at the back end of the firebox.

5.—In group "S," are shown boilers with expansion pads on the side, and these expansion pads are also used on boilers with fireboxes between the frames or directly over the frames. These are mostly of earlier date than those marked "F" and "B."

6.—In group "C" are shown crossties which rest on the frame, tying the two sides of the locomotive firebox together, in most cases acting as support for the grate bars, and in a measure supporting the back end of the boiler under the firebox.

7.—Group "M" represents a special connection used on Mallet locomotives, attaching, with lateral sliding action, the front end of the boiler to the front engine frame.

In the first group marked "G" we have used a suffix, the letter "N," to represent, for ready reference, the devices that are not attached to the boiler. It will be noted that a large proportion of the connections we have shown are attached to the boiler. The information we have shows that where the sheets are very short in depth, less than 5½ in., it is the practice of some to leave them free at the boiler. In this case, a liner is placed on the bottom of the boiler to take up the wear. Some roads, however, use a loose connection for these guide and waist sheets, regardless of the depth, and others report that the loose connection between the sheets and boiler has not been satisfactory and they have changed to a support that is riveted or studded to the boiler.

Several in the group "W" also have the suffix "N" after the numeral, indicating that some of these waist sheets are not attached to the boiler, but form a support for the boiler without any direct attachment.

The most common trouble with both guide yoke and waist sheet connections has been the loosening of the rivets or bolts connecting the sheets with the tee iron on the boiler and connecting the sheets with the frame cross brace. To overcome this trouble at both the guide yoke sheets and the waist sheets, the following improved methods have been developed:

(a) Increasing the number and size of bolts used in attaching the sheets to both the frame cross braces and to the boiler tee irons.
(b) Riveting of extra plates at the top and bottom to provide additional bearing of the bolts or rivets. See Fig. W-15.
(c) Putting in a double set of sheets at the particular points, in order to get double bearing areas without decreasing the flexibility. See Fig. G-8.
(d) Providing a lip on the frame cross braces so that the sheets can rest on this lip and thereby afford better support. See Fig. W-9.
(e) Use of cast steel expansion plates with the flange which is attached to the boiler cast integral with the plate. See Fig. W-13 and Fig. G-13.
(f) Use of cast steel expansion plates with the flange cast integral with the plate for attachment to the frame crossties, as well as to the boiler. See Fig. G-13 and W-13.
(g) Doubling the bolt bearings by using two plates riveted together and two angles on boiler. See Fig. W-10.
(h) Application of a sheet between the bottom of the tee iron on the boiler and the top of the frame crosstie by placing it alongside the main expansion sheet and welding it to the bottom of the boiler tee. See Fig. W-7 N.
(i) Use of a cast steel tee fitted to the proper radius and attached to the boiler, with the leg of the tee machined with a ledge so as to fit the top edge of the expansion sheet; the lower end of the expansion sheet having machined fit to the frame crosstie. This method provides full bearing of the sheet, both top and bottom, and the sheet can be easily fitted. This looks like an exceptionally good method. See Fig. W-9.
(j) In some cases, in addition to the guide yoke expansion sheets, columns have been introduced between the guide yoke cross bar and the boiler, attached at the bottom to the guide yoke cross bar and at the top to a bracket on the boiler. This provides additional support between the guide yoke and the boiler, and also helps to support the guides. See Fig. G-4.
(k) Another group shows columns at the outer end of the guide yoke support, reaching from the guide yoke to brackets on the boiler. In one case they are attached to both the guide yoke and to the boiler, with flexible connections, which allow expansion. This is reported by the railroad using it as being very satisfactory, but they only report its introduction during the year 1926, so that there may be further developments in connection with this device. See Figs. G-14 and G-16.

The second group of troubles in connection with the guide yoke braces and waist sheet connections at the boiler is of more recent development. It is the cracking of the boiler at the ends of the tee irons or other connections between the sheet and the boiler, due either to weaving of the boiler or because these sheets on the larger boilers do not reach up as far as they do on smaller boilers. The earlier use of this form of attachment was in connection with smaller boilers.

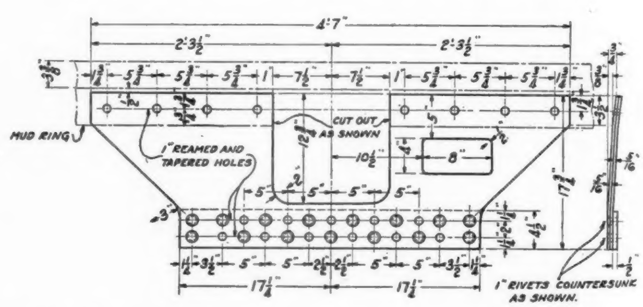


Fig. 7—Back end connection between frame and firebox, design B-9

To counteract this trouble, several improvements have been developed. They are shown on the different drawings, and are as follows:

(a) Cutting away of the bottom leg of the tee iron so as to make the flange more flexible where it comes in contact with the boiler. See Figs. W-1, W-2, W-3 and others.
(b) Introduction of a reinforcement in the form of a liner inside of the boiler shell at the top and of the tee iron or angle iron connected to the boiler. See Fig. G-10.
(c) Introduction of reinforcing pads on the outside of the boiler between the tee iron and the boiler, and extending beyond the ends of the tee iron at the top, Figs. W-11 N, W-14 and W-15, and, where the tee iron is not continuous, extending beyond the tee iron at the bottom also. See Figs. W-10, G-9, G-3, G-14 and G-15. In some cases the tee iron

is fastened to the boiler shell as well as to this outside reinforcing plate. See Figs. W-14 and W-15. In other cases, it is fastened to the reinforcing plate only and the reinforcing plate is riveted to the boiler shell. This latter arrangement is very satisfactory. See Fig. G-9.

(d) Use has been made of inside reinforcing plates in the form of liners, extending around the bottom of the boiler. The tee iron connections are also sheared at an angle so that the line of contact will not coincide with an element of the cylindrical portion of the boiler shell, in this way, reducing the probability of longitudinal crack in the boiler. See Fig. W-12. This arrangement is reported as satisfactory. Notice that the studs or rivets fastening the tee iron to the boiler pass all the way through both the shell and the inside lining. In connection with this lining, as well as in connection with the outside plates for reinforcement, it is to be noted that the ends of these reinforcing plates are not cut off straight across at the ends, but are tapered in such a way that the line of demarkation of the forces does not coincide with an element of the boiler shell.

(e) An arrangement reported as satisfactory is in connection with the fastening of the expansion sheet. A cast steel tee is attached directly to the boiler and riveted to the boiler, but without any lining. This is planed out to a radius to fit the boiler. A special feature of this device is the thinning at the outer ends, thus making it more flexible, and reducing the probability of sharp line of forces coinciding with an element of the boiler, and in this manner preventing a condition liable to develop a crack in the shell. A note on this drawing calls for a maximum thickness of ½ in. for the outer ends, while these ends are tapered so as to further reduce the probability of a sharp line of demarkation of the forces of reaction between this cast steel tee and the boiler shell. See Fig. W-9.

It is well here to call attention to the fact that on the group of illustrations marked "G" and "W," the following information is shown: Thickness of plate, depth of plate, distance from the center of cylinder to the expansion plate.

This is for the purpose of enabling those studying the construction of these devices to form an estimate as to just how much expansion movement they are expected to take care of.

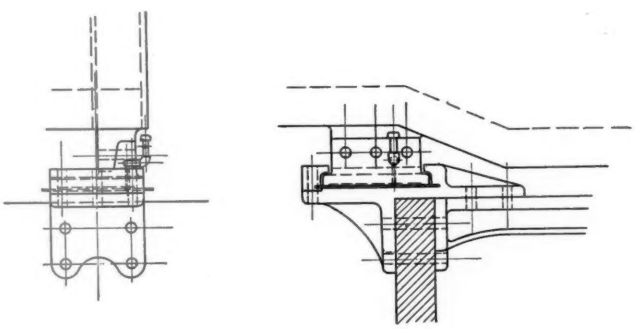


Fig. 8—Front connection between frame and firebox, design F-11

At this point, attention is directed to the attachment of the front barrel ring of the boiler to the front or low-pressure engine on Mallet locomotives. In this connection, we have prepared three drawings, designed "M." The first, Fig. M-1, illustrates the connection between the floating casting attached to the barrel ring of the boiler with either bolts or rivets. Fig. M-2 shows a liner introduced at the extreme ends of this casting in order to reinforce the boiler at this point. Fig. M-3 shows this saddle casting attached to the boiler with a strap passing around the boiler. The casting bears against the reinforcing piece on the outside of the boiler and the reinforcing piece is riveted to the boiler. This serves a double purpose: To prevent wear of the boiler sheet; and also to distribute the forces of action between the boiler and the saddle at their extremities. In some cases, these saddle castings are held in the fore and aft position by being attached with rods to the cylinder. In some recent constructions, they are without this attachment, and so far, have given no trouble.

FURNACE BEARERS

The next general group is in connection with furnace bearers; we have segregated these into four different types.

We will refer first to the illustrations in the group marked "S," as they represent the earliest types and were used largely in connection with locomotives with narrow fireboxes, where they passed down between the frames, or where they passed between the driving wheels. The arrangements shown in Figs. S-1 and S-2 are for locomotives where the firebox sits between the frames. This arrangement was very serviceable during the period when locomotives of this type were constructed.

The link support shown in connection with Fig. S-3 came into use in connection with locomotive fireboxes that reach over the top of the frame, but not beyond the inside of the driving wheels. This attachment was used to a considerable extent at one time, but never proved entirely satisfactory, in that it does not brace the boiler and frame against relative lateral movement.

There are illustrated in Figs. S-4 to S-8, inclusive, details of a variety of designs representing boiler furnace bearers for locomotives where the furnace extends over the top of the frame, but not beyond the wheels. These various types illustrate the changes brought about by the differences in design of the other parts of the locomotive. All have in mind the same idea; viz., to furnish the longitudinal sliding movement on the frame; to confine the frame and boiler laterally in their proper relationship, and to tie the frame and boiler together. Various methods are used to take care of this situation. These can be readily understood by examination of the different drawings. The main feature seems to be to have a good wearing pad between the mud ring of the boiler and the frame so as not to wear either the mud ring or the frame; to provide a strong, serviceable attachment between the expansion pad and the firebox, so that it is not liable to come loose at the points where the parts are studded together. These devices have proved very serviceable, and if locomotives were built at the present time with fireboxes so narrow as not to reach beyond the driving wheels, devices of this type would undoubtedly be used generally, but at present, they are used only for locomotives that have been in service for a long time, or for small locomotives.

For the front furnace bearers, there are a variety of designs, both of the expansion plate and slide type.

Fig. F-1 represents an expansion plate between the bottom of the mud ring and a crosstie mounted on the frame. This is reported as unsatisfactory. It will apply only to light locomotives.

Fig. F-2 represents a sliding contact between the frame and a cross brace attached to the throat sheet, and resting on the frame. This serves to brace the two frames together, and prevents lateral movement between the firebox and the frames. This connection allows fore and aft movement. The detail does not show that the firebox is tied to the frame. This may have been done, but the illustration does not so indicate.

Fig. F-3 represents an early design of the expansion sheet at the front of the firebox; this is also reported as unsatisfactory. It is noted that it does not rest on the frame crosstie at the bottom, but the expansion sheet rests upon and is bolted to brackets, pointing inwardly from each frame toward the center—in this way making the expansion sheet itself a crosstie. The upper portion of this expansion sheet depends entirely upon the bolts to carry the load, and there are not many bolts.

The design shown in Fig. F-4 represents a decided effort to secure flexibility in the plates. It is reported as unsatisfactory.

Fig. F-5 represents a sliding contact between the locomotive frame and a shoe attached to the front end of the mud ring There is a wearing pad between the top of the frame and the bottom of the shoe to prevent wearing of the frame at this point.

Fig. F-6 represents a sliding pad at the front of the firebox, bearing on the frame, in connection with an expansion sheet of cast steel in the form of a truss, which is attached to the mud ring on the front side at the center and rests upon the bottom rail of the frame. The cast steel trussed expansion plate is not attached to the top rail of the frame but has feet bearing against the frame. This allows for the movement by the flexibility of this casting. Neither the pads on the top rail, nor the expansion sheet are arranged so as to tie the two locomotive frames together.

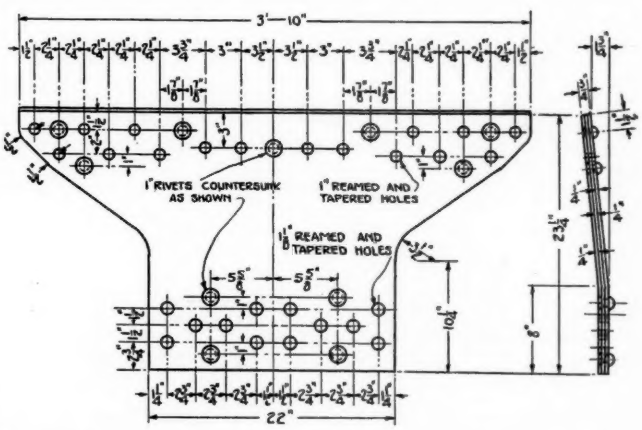


Fig. 9—Front connection between frame and firebox, design F-12

Fig. F-7 shows a flexible sheet supporting the front end of the firebox. This sheet is attached to the frame through two crossties one resting on the top of the bottom rail, and the other fastened underneath the bottom of the top rail. This sheet is attached to the crossties with bolts and rests against a prepared surface on the front end of the mud ring. This appears to be a reliable device, but is reported as unsatisfactory.

Fig. F-8 shows a shoe attached to the mud ring at the front

and keyed to prevent relative lateral movement on the mud ring. Through this device the locomotive frames are tied together. Steel wearing plates are used between shoes and the frame. An oiling device is used.

Fig. F-9 represents a combination at the front end of the firebox, of a sliding device resting upon a frame casting, spreading from frame to frame, with an expansion plate which is fitted between ledges on both the cast steel frame crosstie and the bottom of the mud ring. This expansion plate is also bolted top and bottom. It is reported as being satisfactory. From appearances, it offers a substantial support and provides the very best attachment possible between the boiler and the frames.

Fig. F-10 illustrates the use of an expansion plate at the front end of the firebox. The bottom of the plate rests upon a prepared ledge on a cast steel crosstie, and the top of the sheet rests against a prepared ledge on the bottom side of the mud ring. In addition to these ledges, there are an ample number of bolts used to attach the sheet to both the mud ring and the frame crosstie casting. This is reported as very satisfactory.

Figs. F-11, F-13 and F-15 represent construction of front furnace bearers with sliding pads resting on top of castings which are attached to cross frame braces. Fig. F-11 shows an adjusting sheet to take up the vertical wear and also shows an oil cup. Both of these are good features. This design is reported as being very satisfactory.

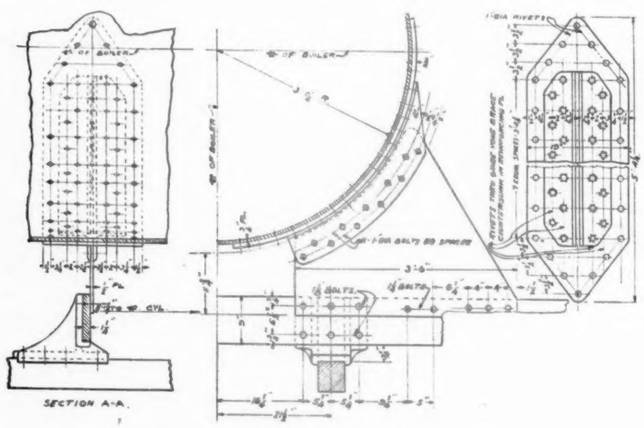


Fig. 10—Guide brace, design G-9

Fig. F-12 shows an arrangement of an expansion sheet giving both great flexibility and large supporting capacity. These are obtained by using three thin sheets placed one against the other, giving the carrying capacity of a thick sheet, and the flexibility of a thin sheet. The arrangement is reported as being very satisfactory.

Fig. F-14 shows a front furnace bearer expansion sheet made from a thick sheet, left thick at both top and bottom sides to give large bearing surfaces for connections with both mud ring at the top, and frame braces at the bottom. The center portion of the sheet is thinned to allow flexibility. This is better than a riveted reinforcement at the edges, but is much more expensive. This form of construction is applicable to any of the expansion sheets.

Fig. F-16 is a similar slide to that shown in Figs. F-11, F-13 and F-15, but without any frame crosstie. This arrangement is reported as being satisfactory.

The back furnace bearers are shown in a group of sketches, marked "B." Fig. B-1 shows a device designed in the form of a backhead brace that was used for light engines, in order to support the back end of the frame when jacking. Expansion is arranged for by the use of a slotted hole in the foot of this brace.

Fig. B-2 shows the rear furnace bearer in the form of a knee brace studded to the back end of the boiler with the extending flange resting on the foot plate.

Fig. B-3 shows a sliding shoe. This is used in connection with the back end of the firebox when it overreaches the frames. It shows the mud rings set well above the engine frame, and the shoe carried on a bracket attached to the frames to fill the distance between the shoe and the frame. The brackets on the two frames are tied together with a deep plate, which plate also serves as a support for the other parts. This is a very satisfactory device.

Fig. B-4 shows an arrangement of a single sheet which is flexible in the direction of the boiler expansion. It shows the top portion of the sheet fitted against the bottom of the mud ring, and the bottom portion of the sheet fitted on a ledge at the front end of the foot plate and fastened both top and bottom with bolts.

Fig. B-5 shows a link connection fastened on the backhead of the boiler. This link is attached to a bracket with a pin, the bearing surface of which falls outside of the locomotive frame. This would not seem to be a very stable device. It furnishes no more lateral confinement of the rear end of the boiler than does the link placed on the side of the boiler.

Fig. B-6 shows an arrangement of expansion sheets cut in three pieces across the engine, the outside parts reacting against the back spring hanger brackets.

Fig. B-7 shows a sliding arrangement used in connection with the back corner of a narrow firebox. This arrangement is a very good one in that it furnishes all the needed support laterally and vertically, and, at the same time, allows for the necessary longitudinal boiler expansion. It also furnishes the desirable wearing pad between the furnace bearer and the engine frame, and a secure attachment to the mud ring, offering resistance to any lateral movement.

Fig. B-8 and B-10 show sliding brackets for the back end. These are similar to a number of those that have been shown in connection with the front end of the firebox. These can rest directly on the back foot plate, or on the special pads cast on the rear cradle casting of the engine frame.

Fig. B-9 shows an arrangement of expansion sheets, two being placed together in such a way as to get ample support with great flexibility. This arrangement is reported as being very satisfactory.

Fig. B-11 shows a very wide expansion sheet at the back end. This expansion sheet is reinforced, both top and bottom, with an extra thickness of plates. This brings about additional bearing on both at the top and bottom, thus taking care of the bolt and rivet bearing and shearing. This is reported as a very satisfactory arrangement.

Furnace Crossties and Grate Bar Supports

Fig. C-1 represents a furnace crosstie and grate bar support which is attached to the bottom of the mud ring, between the front and back ends, and is also rigidly attached to the frames. The arrangement is such that it makes necessary the springing of the parts in order to take up the boiler expansion.

Fig. C-2 represents a furnace crosstie located across the furnace between the front and back ends. This ties the two frames together, as well as the sides of the mud ring. This is arranged to allow fore and aft sliding movement, and take care of the expansion, but does not secure the frame against separation from the mud ring.

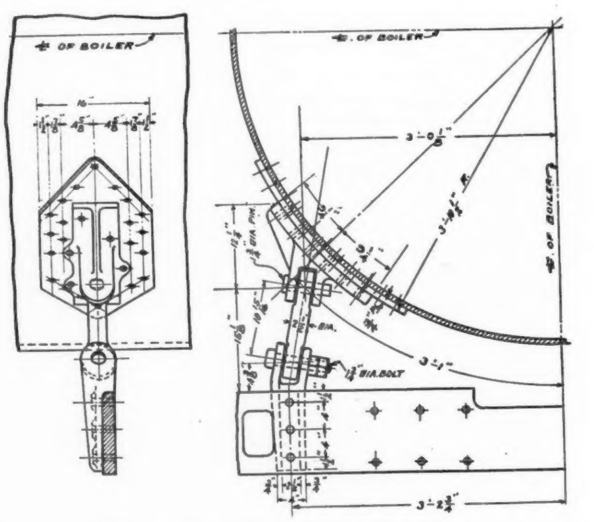


Fig. 11—Guide brace, design G-14

Fig. C-3 is similar to Fig. C-1. It is used in connection with a very wide firebox, and its main purpose seems to be to support the grate bars. The arrangement is such that the parts have to spring in order to allow the expansion of the boiler on the frame. It serves, however, both as a firebox crosstie and as a frame crosstie.

In review of the various methods employed as shown in the report for securing the boiler to the locomotive frame, the following general recommendations are made:

1—Waist sheets should be rigidly attached to the boiler shell.

2—Waist sheets and other connections between the frames and boilers of locomotives should be provided with a reinforcing liner interposed between the angle or "T" iron and the boiler shell.

3—Furnace bearers between mud ring and frame, when used, should be of sliding type and provided with bronze liners.

4—Front and back of firebox be supported with a plate as deep as possible to provide flexibility. Top and bottom of plate to be reinforced to provide ample bearing area for bolts.

5—Where possible, supporting sheets should be machined to fit in a shoulder on the part to which attached to relieve stresses on the bolts.

The report of the subcommittee on Provision for Expansion of Locomotive Boilers on the Frames is signed by A. Kearney (chairman), W. L. Bean and H. H. Lanning.

Exhaust steam injectors

[The subcommittee, consisting of G. H. Emerson (chairman), H. A. Hoke and R. M. Brown, recommended that the subject be continued for further report.—Editor]

Boiler pressures higher than 200 lb.

During the last few years, opinion has been gradually crystallizing in favor of higher boiler pressures for steam locomotives. From present activities, we appear to be entering an era of thermo-dynamic improvement, similar to that brought about by the introduction of superheating, some 20 or 25 years ago, and as the latter had its greatest impetus from German engineers, so, at the present moment, it appears that the Germans

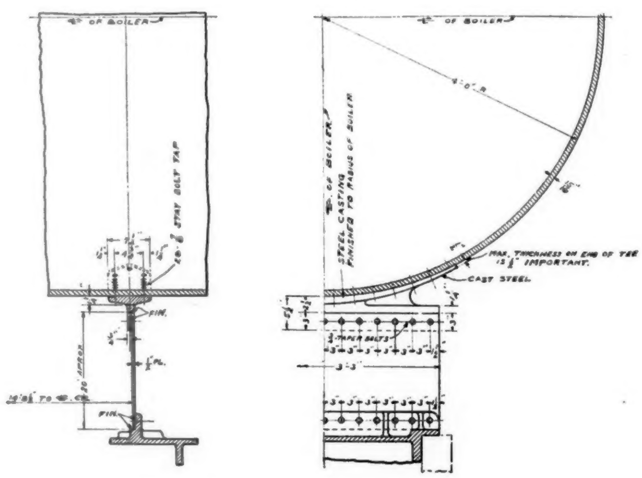


Fig. 12—Waist sheet connection, design W-9

are just now taking the lead in the development of ultra locomotive boiler pressures, closely followed by the Swiss.

The outstanding advantage of high pressure; namely, extra available heat energy from a given fuel, will continue to invite the activities of engineers working on different lines of thought, which will advance development toward the ultimate goal of what we consider today as ultra-pressure. There are greater difficulties to overcome in the development of high steam pressures than in the development of high steam temperatures by superheating. On the other hand, the incentive for economy today is much greater than 25 years ago.

While no serious attempts have been made in this country to use ultra-high pressures, there are a large number of locomotives running with the lower range of high pressures. There are somewhat over 1,000 American locomotives using 250 lb. pressure, and others being constructed. As a whole, there are no distinctive departures from convention in the design of these locomotives, excepting that they are as a rule arranged for limited cutoff—usually 50 or 60 per cent maximum.

There are also a number of locomotives operating on one road in which a boiler pressure of 265 lb. is used. These are equipped with McClelland water-tube firebox boilers, but in other respects of conventional design.

The use of pressures above 265 lb. is apparently confined to the following examples: The Delaware & Hudson "Horatio Allen," using 350 lb. boiler pressure; the "John B. Jervis," of the D. & H., which will use 400 lb. boiler pressure, and the Baldwin Locomotive Works No. 60,000, which uses 350 lb. steam pressure. Data from the Altoona test plant is now published and shows this locomotive as having produced greater fuel economy than any other locomotive tested in this plant, and service tests on several prominent roads appear to sustain these figures.

As a result of the use of higher pressures, limited cutoff and compounding, locomotives of the types mentioned show favorable reduction in steam consumption; in most instances an increase in tractive effort.

Several other roads are at present favorably considering new locomotive design including steam pressures from 400 to 500 lb.

European developments

European experiments and developments in high-pressure locomotives embrace a variety of ideas, some of which are a distinct departure from present accepted practices. Particularly are European engineers and railway men interested in pressures in excess of those under present consideration in America.

Several high pressure locomotives have been constructed and are under test on European railways. Some of these have interesting possibilities. As no detailed information is available on most of this experimental equipment, the descriptions contained herewith are necessarily brief.

The "Schmidt-Henschel two-pressure" locomotive is an unusual unit which was constructed at the Henschel-Sohn works at Cassel, Germany. It is now undergoing test operation on the German State Railways.

Three pressures are produced in the boiler, although but two, the 850 lb. and the 200 lb., are working pressures. The 850 lb. pressure is superheated to about 716 deg. F. and worked expansively in a center high-pressure cylinder. It is exhausted at about 200 lb. pressure, mixed and reheated with fresh superheated steam from the low pressure part of the boiler and then expanded in the two low-pressure outside cylinders. The low-pressure steam is highly superheated so that the resultant temperature, after mixing with the steam which has been cooled by cylinder expansion, is at a temperature of about 660 deg. F., as it goes to the low-pressure cylinders. The final exhaust is through the stack in the usual manner. A feedwater heater and sediment separating arrangement is provided for the low-pressure boiler, and feedwater for the high working pressure drum is pumped from the low-pressure boiler.

Some of the advantages expected of this design are as follows:

1—Freedom from scale in the firebox portion of the boiler, because of the use of distilled water; the absence of fire contact surfaces and the use of clean water in the drum portion; and the lower pressure and sediment separation arrangement in the low-pressure part of the boiler.
2—Freedom from cylinder condensation because of the reheating effect of the highly superheated low-pressure steam upon the expanded steam with which it is mixed as it passes to the low-pressure cylinders.
3—Relatively high overall economy as a result of the inherent economy of the high-pressure steam, reheating and compounding, and the efficient heat flow from flame and hot gases to the water.

This locomotive was converted from an ordinary three-cylinder locomotive developing originally 1,800 hp. In its present high-pressure form the output is 2,000 hp. No operating data indicating the efficiency obtained is as yet available, but your committee is in correspondence with Henschel & Sohn, also the German State Railways, to develop this data. We have learned in a general way that the results of preliminary tests are very encouraging.

Buchli locomotive—Another development worthy of attention is a high-pressure locomotive designed by Dr. Buchli and built by the Swiss Locomotive Works, Winterthur, Switzerland. The boiler is a water-tube type developing 800 lb. direct pressure and is equipped with feedwater heater, superheater and air preheater.

The engine is very unusual, being a small high speed three-cylinder, horizontal, uniflow type with poppet admission valves—the cylinders are only 10 in. diameter. All parts are enclosed and run in oil, including filter, force-feed and oil cooler. It is geared to the drive wheels with two to one ratio gears and, being a complete unit, can be removed as such from the locomotive. The exhaust pipes or passages from each of the three cylinders terminate in a "Y" formation so that each exhaust impulse will produce an ejector effect on the two other cylinders and thus reduce the effective back pressure.

Some advantages Dr. Buchli is striving for, and from indications of tests may attain, are:

1—High overall efficiency.
2—Low first cost, and reduction of wear and cost of servicing through use of small light weight reciprocating parts.
3—Ability to operate at a high cutoff point. It will start loads at 27 per cent, shows good indicator cards at from 9 to 12 per cent, and operates easily at 5 per cent cutoff.
4—Elimination of dynamic augment as counterbalancing of revolving parts only required.
5—Low adhesion factor because of the twelve impulses per revolution of drive wheels.

In preliminary tests this locomotive is reputed as showing a net efficiency of 11 per cent and a smooth performance mechanically. The Buchli design as a whole represents a marked departure from conventional design, both as to boiler and machinery, and illustrates the boldness of European locomotive designers.

Maffei turbine locomotive—Still another development of a different character is the Maffei turbine locomotive built by J. A. Maffei of Munich, Germany, for the German State Railways. This locomotive develops 2,500 hp. and was designed to haul heavy express trains at an average speed of 62 m.p.h. The design is particularly adapted for high speed.

The turbine is mounted at the front and is geared to a jackshaft from which the final drive to three pairs of drivers is by side rods. The exhaust steam is condensed in two surface type condensers mounted, one on each side of boiler, below running boards, the water for condensers being air cooled in the water

cooler portion of the tender. A turbine-driven fan creates the necessary draft for ejection of waste furnace gases., Mechanical draft becomes a simpler problem when handling the waste gases only. Other auxiliaries are likewise turbine driven. Of particular interest is the use of 324 lb. pressure in the boiler of ordinary stayed sheet firebox type.

This locomotive is a highly advanced example of engineering skill and may indicate one of the several means toward attaining high economies with steam locomotives. Advantages anticipated from this design are:

1—High overall economy as a result of high steam pressure. turbine drive and condensing. The builders expect an efficiency at the turbine jackshaft of 15.6 per cent at a speed of 43.5 m.p.h.
2—Lighter total weight per horsepower, these particular locomotives being 18,000 lb. lighter than corresponding lower pressure reciprocating types of equal output.
3—Elimination of dynamic augment as the counterbalancing of the side rods only is required.
4—Low adhesive factor as a result of the uniform torque.
5—Freedom from scale formation because of the condensing.
6—Quietness of operation.

Ljungstrom turbine locomotive—Another locomotive using pressures higher than ordinary in a boiler of conventional type is the Ljungstrom turbo-locomotive. This is a Swedish design, the first being constructed in Sweden for the railways of that country and later, one in England for use in that country. The steam is produced at a pressure of 285 lb. in a boiler of conventional construction, mounted upon a framing and wheels forming the "boiler vehicle" or forward part of the locomotive, but contributing none to the adhesive weight. The turbine, which is of 2,000 hp. capacity, is mounted upon the tender or rear portion of the locomotive and geared to the wheels thereof. The advantages and disadvantages of this type of locomotive correspond practically to those mentioned in the description of the Maffei turbine locomotive, the variation in design being in the details rather than in general principles.

Comparative performance tests were made with turbo and reciprocating types of locomotives, figures given being pounds of coal per 1,000 ton miles:

Turbo locomotive—highest, 45.5 lb.; lowest, 39.1 lb.
Reciprocating locomotive—highest, 130 lb.; lowest, 82.9 lb.

Comparing the average turbo performance with the lowest for the reciprocating type shows a saving in coal consumption of 49 per cent. The comparison would be a less favorable one if made with some of the latest examples of American locomotives.

Other forms of turbo-locomotives, such as the Krupp and Zoelly designs, which are to be adapted to the use of high pressures, are under development and test.

Krupp turbine locomotive—This locomotive as now being constructed is to have a maximum output of 2,500 hp. and use a pressure of 854 lb. The boiler is constructed similar to the Thorncroft-Schultz marine boiler, that is, with top and bottom drums connected with water tubes. Construction of this locomotive will not be completed until tests of the present Krupp low pressure turbo-locomotives are completed.

In consideration of turbine locomotives which seem particularly well adapted to the use of high steam pressures, some factors must be considered which counteract to an extent the advantages derived therefrom. They at present seem to be adapted principally to high speed passenger service, are relatively complex in design and construction, and the first cost is much greater than conventional designs. In Germany this increase in cost has been found to be about 80 per cent, although development may reduce that figure somewhat. If the economies expected are realized, the first cost may become of secondary importance.

Loeffler locomotive—Two locomotives of the piston type are being built by the Berlin Machine Builders to the designs of Prof. Loeffler. These locomotives are reported by Dr. Wagner of the German State Railways to have characteristics about as follows: 2,500 hp.; boiler pressure, 1,422 lb. The boiler consists of a high-pressure drum containing water and a tube type superheater.

Saturated steam is pumped from the drum through the superheater coils, 25 per cent of the steam going to the engine cylinders and the balance returning to the boiler drum, where it is injected into the water. Here it gives up its residual heat to the water; generating saturated steam which continues on through the cycle. The steam used in the cylinders after performing its work is condensed and the water returned to the boiler. Hot combustion gases come in contact only with coils or boiler tubes containing steam. A fuel economy of 45 per cent is anticipated, compared with usual conventional design.

In addition to the examples cited, other high-pressure experimental locomotives are under construction, but concerning which little information is at present available.

Present and future locomotive developments

There are greater difficulties to be encountered in the construction of high-pressure water-tube boilers and their associated working apparatus in the case of locomotives than in stationary plants, particularly in the matter of space limitation, yet undoubtedly some of the knowledge gained in the high-pressure stationary experimentation can be made use of in connection with locomotive work.

In connection with design and construction of locomotives using high-pressure steam—there are two major problems which must be given due consideration and study. They are: First, the means of producing the high-pressure steam, viz.; the boiler and its various associated appurtenances; and second, the apparatus for working or using the steam, whether piston type engine or turbine, and its various associated or connected parts. It is necessary that we feel our way, try various ideas and select those that survive through their natural fitness.

There is one requirement which must not be overlooked—that of reliability. The ability to move the traffic over the road at all times and under all conditions, good or adverse.

The fire-tube boiler now in general use is reliable, compact, low in first cost, has great evaporative capacity in relation to space occupied; and in addition it has the advantage of great energy storage capacity which is of value on account of the sudden fluctuation of demand upon the motive unit.

It is, however, limited somewhat by reason of the excessive thickness and weight of sheets required for high pressure, this being the reason for adoption of water-tube principle in most of the recent experimental units. The general use of higher boiler pressures which seems inevitable spells the doom of the boiler with staybolted surfaces; and, with our staybolt troubles, we should not be sorry to see it pass. The Brotan, McClellan, Muhlfeld, and other boilers are indicative of the trend toward water-tube. These boilers operate under pressures of 250 to 400 lb. Higher pressures than these will compel a still further application of the water-tube boiler principles to the extent of displacing the shell and fire tubes.

The use of alloy steels will assist in the reduction of this limitation as is apparent by the use of nickel steel on some Canadian Pacific locomotives whereby it was possible to increase the steam pressure from 200 to 250 lb. with no increase in the thickness of the boiler shell, firebox sheets and diameter of stays.

Controversial ideas have been expressed as to the maximum pressure practical to use in the ordinary stayed type of firebox, these centering largely on a pressure of 250 lb. as a limit. Upsetting somewhat this arbitrary limit, it is noted that two European locomotives previously described are using pressures of 285 lb., and 324 lb., in boilers of ordinary construction. These are the Ljungstrom and Maffei turbo-locomotives. These are of course smaller than prevailing American equipment, and the pressures indicated are lower than those now contemplated by many designers.

In connection with the construction of water-tube boilers for locomotives, some difficulties may be encountered in keeping tube connections tight, and it is more difficult to construct a rigid unit such as is required in locomotive work, than is the case with conventional type of boiler. Some loss in heat storage capacity will result from the reduced volume of water under pressure, but this may be compensated for to an extent by more flexible steaming capacity.

One difficulty which may present serious aspects in connection with the high-pressure boiler lies in the very general use of untreated water. With the high temperature used this may be serious and washing and cleaning may become burdensome. Boilers so designed as to obtain a rapid circulation will avoid much of this difficulty. The use of condensing as on turbo-locomotives would, if practical to apply to our large units, practically solve this difficulty. Experience with the Brotan, McClellan and Muhlfeld water-tube firebox indicates that scale formation, cleaning and inspection, does not present the difficulties that were expected and it is possible that with reasonably good water, difficulties along this line will be minimized.

Many conceivable arrangements may be suggested for the working or expansion cycle of a high-pressure locomotive. The use of high-pressure steam and multicylinder design tends to improve the construction through the use of smaller parts and the greater possibilities for work production of high-pressure steam. The multicylinder construction reduces the necessary adhesion weight on account of more uniform torque action, this approaching to a certain extent that quality which is quite characteristic of the turbine.

Turbine locomotives have some interesting possibilities, although those built so far in Europe do not exceed 2,500 hp., being of smaller capacity than would be required for general service in America. The designing of a condenser for turbine locomotives of 4,000 or 5,000 hp. might present quite a problem.

Proper superheating will, of course, be important, but rather than add a high initial superheat, it seems preferable to use a moderate initial superheat, expand the steam in more than one stage, and reheat between stages. Losses from condensation

would be reduced and the superheating between expansion stages would be effective because of the greater temperature difference at that time between the steam and the furnace gases.

Your committee does not feel that the present-day development of the higher pressures offers opportunity to suggest any recommendations, and desires this paper to be accepted as an outline report.

The report of the subcommittee on High Boiler Pressures is signed by A. H. Felters, (chairman), W. I. Cantley, H. M. Warden and M. F. Cox.

Oil-electric locomotives

The committee report covers the development of design of oil-electric locomotives; the status of application of the oil-electric locomotive to railroad service, and operating costs.

Recommendations for future work

The following subjects are recommended for future work: Continue study and make report on development and use of the oil-electric locomotive in railroad service; continue to collect operating information and, if practical, analyze operation costs, and include oil-engined locomotives whose transmission is other than electric, such as the electro-magnetic clutch proposed for the B. & M.

Development in design

The development in designs of oil engines for locomotive work in railroad service is little changed from last year. The desire for this type of prime mover has been largely inspired by demand for

a. Smokeless, self-contained motive power unit.
b. Lower operating costs for switching service.

The development of the oil-electric in light high-speed units, enough to compete with steam locomotives for general road service, in America, has not yet been effected.

Status of application

Table I gives a tabulation and brief specifications of the oil-electric locomotives referred to below. The locomotives for the New York Central are expected to be delivered during the latter half of 1927. The oil engines for the Pennsylvania Railroad have not been delivered to date. The oil engine for the B. & M., which is an electric-magnetic clutch transmission, is under construction in Germany at the Krupp Works at Essen.

Oil-electric locomotives in the United States

Figs. 1 and 2 show the 300 and 600 hp. oil-electric locomotives built by the Ingersoll-Rand Company, American Locomotive Company and the General Electric Company.

Operating costs

The tables cover certain operating costs, over a limited test period as taken from the builders' records and files. These figures cover present hard coal switch engines without modern auxiliaries such as superheaters, feedwater heaters or other devices which may have affected the economic operation. The load factor is the ratio of the actual output to the maximum rating and is expressed in the case of the oil-electric locomotive as the ratio of the actual kilowatt output to the maximum kilowatt rating.

In order to ascertain certain information and operating costs of the oil-electric locomotives in railroad service, over an extended period, a questionnaire was addressed to the chief operating officers of four railroads having this type of power in service over a period of at least one year. During the year 1926, six more railroads and two industrial firms have placed oil-electric locomotives in service and next year their names will be added to the list for the mailing of the questionnaire.

Abstracts of the replies received are presented in table VI. No attempt has been made to analyze these costs at this time owing to the limited number in service over such a short period, and the character of the service to which some of these units have been assigned which makes it difficult to obtain similar comparison of steam locomotives in either yard or other regular railroad service.

Table II—Operating ratios oil-electric locomotives

The following tabulation gives the kilowatt output per gallon and the ratio of lubricating oil to fuel for a number of records on oil and gas electric locomotives, September, 1925, to April, 1926:

	Hour service	Load factor, per cent	K.w.hr. per gal.	Ratio lub./fuel, per cent
1. 60-ton, road A September 1-2, 1925	16	28	8	2.7
2. 60-ton, road A Nov., Dec., Jan., 1925, 1926	1052	10.5	6.02	2.1
3. 60-ton, road A February, 1926	293	8.4	6.06	2.95
4. 60-ton road B January, 1926	162	8.6	5.5	3.6
5. 60-ton, road B February, 1926	214	8.2	5.8	3.3
6. 60-ton, road C January, 1926	394	8.2	6.15	2.6
7. 60-ton, road C February, 1926	365	7.	5.6	2.75
8. 100-ton, road D December 15, 1925	40	33	8.05	1.
9. 100-ton, road D February 15-27, 1926	220	15.1	7.5	1.2
10. 45-ton gas electric—1925	2511	23.7	5.85	2.95

Table III—Comparative operations oil-electric vs. steam

	December Oil-elec. 1925	Steam 1924
Number of days	24	24
Hours of locomotive service	347	297
Operating fuel consuming hours	318	297
Fuel oil used—gallons	1038	...
Diesel lubricating oil used—gallons	25	...
Gasoline used—gallons	5	...
Engine oil used—gallons	5	5
Valve oil used—gallons	10	5
Star cup grease used—pounds	1	...
Kilowatt hours generated	6614	...
Coal used—tons	...	41
Number of floats handled—in	57	47

(*Continued on page* 422)

Table I—Tabulation and specifications of oil-electric locomotives

Country	No.	Locomotive builder	Owner	Engine builder	Electric builder	Hp.	Total weight	Weight per Hp., Eng. only	Weight per Hp., total	Cylinders No. and Size, in.	Cycle	Fuel injection	R.p.m. engine	Wheel arrangement	Date in service
USA	1	A.L.Co.	C.R.R.N.J.	I. R.	G. E.	300	120M	66.7	400	6-10 x15	4	Solid	600	4-4	10-22-25
USA	1	A.L.Co.	B. & O.	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	12-26-25
USA	1	A.L.Co.	L. V.	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	1- 7-26
USA	1	A.L.Co.	C. & N.W.	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	5- 4-26
USA	1	A.L.Co.	Erie	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	5-25-26
USA	1	A.L.Co.	Reading	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	6- 1-26
USA	1	A.L.Co.	D. L. & W.	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	6-23-26
USA	1	A.L.Co.	D. L. & W.	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	7- 1-26
USA	1	A.L.Co.	C. & N. W.	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	10-19-26
USA	1	A.L.Co.	C. & N. W.	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	4-19-27
USA	1	"Utah Copper"			G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	7-23-26
USA	1	A.L.Co.	I. R.	I. R.	G. E.	300	120M	56.7	400	6-10 x15	4	Solid	600	4-4	9-24-26
USA	1	Brill	L. V.	McI.-S.	G. E.	300	52M	90.0	507	12- 8 x 9½	4	Air	500	4-4	U. C.
USA	1	A.L.Co.	L. I.	I. R.	G. E.	600	200M	56.7	333	12-10 x12	4	Solid	600	4-4	12-22-25
USA	1	A.L.Co.	Red Riv.	I. R.	G. E.	600	200M	56.7	333	12-10 x12	4	Solid	600	4-4	8-17-26
USA	1	A.L.Co.	G. N.	I. R.	G. E.	600	200M	56.7	333	12-10 x12	4	Solid	600	4-4	9-24-26
USA	1	A.L.Co.	L. I.	I. R.	G. E.	600	200M	56.7	333	12-10 x12	4	Solid	600	4-4	U. C.
USA	1	A.L.Co.	N. Y. C.	I. R.	G. E.	300	250M	56.7	833*	6-10 x12	4	Solid	600	4-4	U. C.
USA	1	A.L.Co.	N. Y. C.	I. R.	G. E.	750	290M	60.0	388	6-14½x16	4	Solid	500	4-4	U. C.
USA	1	A.L.Co.	N. Y. C.	McI.-S.	G. E.	880	330M	91.0	375	12-14 x18	4	Air	300	4-4	U. C.
USA	3	P.R.R.	P. R. R.	Bessem	West.	500	130M	40.0	260	8- 8½x12	4	Solid	800	0-4-0	U. C.
USA	9	A.L.Co.	Stock	I. R.	G. E.	300	120M	56.7	400	6-10 x12	4	Solid	600	4-4	In Stock
USA	2	A.L.Co.	Stock	I. R.	G. E.	600	200M	56.7	400	12-10 x12	4	Solid	600	4-4	In Stock
USA	1	Bald.	Exp.	Knuds	West.	1000	275M	56.7	275	12- 9¾x13½	2	Solid	450	6-6	1925
Germ.	1	Lormon-Hohenz.	Russia	M.A.N.	Brown-Boveri	1000	262,400	60.7	262	6-17.7x16.5	4	Air	450	2-10-2	1925
Germ.	1	Krupp	B. & M.	M.A.N.	Krupp	1400	314M	71.5	225	6-16.9x16.9	4	Solid	470	4- 8-4	U. C.
Austria	2	Austria State R. R. Grazer				200	......	....	....	....	4	Solid	....	......	U. C.
Italy	1	Fiat	Colobra	Fiat	Brown-Boveri	440	110M	....	250	6	2	Air	500	4-4	1925
Russia	1	Hockel	Russia	Vickers	Elec.	1000	396,840	....	397	10	....	Solid	395	2-20-2	1925

* Oil-electric storage battery switch engine. "U. C." means under construction.

	December Oil-elec. 1925	Steam 1924
Number of floats handled—out	57	46
Number of floats handled—total	114	93
Tons handled off floats	38889	31040
Tons handled on floats	22667	19453
Tons handled total floats	51556	50493
(Includes tare weight of cars)		
Number of cars handled—in	947	775
Number of cars handled—out	943	765
Number of cars handled—total	1690	1531
Daily average		
Hours of locomotive service	14.5	12.4
Operating fuel consuming hours	13.3	12.4
Fuel oil used—gallons	43.2	...
Diesel lubricating oil used—gallons	1.04	...
Gasoline	Neg.	...
Coal used—tons	...	1.7
Kilowatt hours generated	275	...
Number of floats handled	4.75	3.87
Number of cars handled	79	64
Number of tons handled	2565	2104
Cost of fuel, oil, coal, etc.—total	$2.98	$14.56
Operating hourly average cost		
Fuel, oil, coal, water, etc	$.228	$1.18
Per car on and off floats	.038	.228
Per ton on and off floats	.0011	.0069
Cost per KW hour	.0109	....
Cost of operation		
Fuel oil at 5¢ per gallon	$51.90	...
Diesel engine lubricating oil at 53¢ gal	13.25	...
Gasoline at 14.5¢ gallon	.72	...
Water at $1.00 per 1,000 cubic feet	.03	$28.37
Engine oil, .262 per gallon	1.31	1.31
Valve oil, .53 per gallon	5.30	2.65
Star cup grease, .07 per pound	.07	...
Coal cost, 7.15 per ton	...	293.15
Coal cost handling	...	24.00
Total cost of fuel, coal, oil, etc	72.58	349.46

Table IV—Comparative operations oil-electric vs. steam

	January Oil-elec. 1926	Steam 1925
Number of days	25	27
Hours of locomotive service	407	315
Operating fuel consuming hours	380	315
Fuel oil used—gallons	1212	...
Diesel lubricating oil used—gallons	25	...
Gasoline oil used—gallons	5	...
Valve oil used—gallons	10	5
Star cup grease used—pounds	1	...
Kilowatt hours generated	7025	...
Coal used—tons	...	48
Number of floats handled—in	57	41
Number of floats handled—out	57	44
Number of floats handled—total	114	81
Engine oil used—gallons	5	5
Tons handled off floats	39902	26864
Tons handled on floats	22892	16767
Tons handled—total	62794	43641
(Includes tare weight of cars)		
Number of cars handled—in	942	672
Number of cars handled—out	949	650
Number of cars handled—total	1891	1322
Daily average		
Hours of locomotive service	16.2	11.7
Operating fuel consuming hours	15.2	11.7
Fuel oil used—gallons	48	...
Diesel lubricating oil used—gallons	1	...
Gasoline	Neg.	...
Coal used—tons	...	1.8
Kilowatt hours generated	281	...
Number of floats handled	4.56	3
Number of cars handled	76	49
Number of tons handled	2511	1616
Cost of fuel, oil, etc	3.35	14.91
Operating hourly average cost		
Fuel, oils, coal, etc	$.213	$1.27
Per car on and off float	.043	.304
Per ton on and off float	.0013	.0092
Cost per KW hour	.0115	.....
Cost of operation		
Fuel oil, 5¢ per gallon	$60.60	.....
Diesel engine lubricating oil. 53c per gal	13.25	.....
Gasoline, 14.5¢ per gallon	.72	.....
Water, $1.00 per 1,000 cubic feet	.03	$28.36
Engine oil, .262 per gallon	1.31	1.31
Valve oil, .53 per gallon	5.30	2.65
Star cup grease, .07 per pound	.07	.....
Coal, 7.15 per ton	...	343.20
Coal handling	...	27.00
Total cost of fuel, etc	81.28	402.52

Table V—Comparative operations oil-electric vs. steam

	February Oil-elec. 1926	Steam 1925
Number of days	24	23
Hours locomotive service	312	295
Operating fuel consuming hours	293	295
Fuel oil used—gallons	812	...
Diesel lubricating oil used—gal	24	...
Gasoline	5	...
Engine	5	5
Valve	10	5
Star cup grease	1	...
Kilowatt hours generated	4921	...
Coal used—tons	...	40
Number of floats—in	41	39
Number of floats—out	41	39
Number of floats—total	82	78
Number of cars off float	674	655
Number of cars on float	673	631
Number of cars—total	1347	1286
Tons handled off floats	26285	27764
Tons handled on floats	16061	16031
Tons handled total floats	42346	43795
(Includes tare weight of cars)		
Cost of operation		
Fuel oil, 5¢ per gallon	$40.60	...
Diesel engine lubricating oil, 54¢ per gal	12.96	...
Gasoline, 14½¢ per gallon	.72	...
Water, $1.00 per 1,000 cubic feet	.03	$26.86
Engine oil, .252 per gallon	1.31	1.31
Valve oil, .53 per gallon	5.30	2.65
Star cup grease, .07 per pound	.07	...
Coal, $7.15 per ton	...	286.00
Coal handling	...	24.00
Total cost of fuel, etc	60.99	340.84
Daily average		
Hours of locomotive service	13	12.8
Operating fuel consuming hours	12	12.8
Fuel oil used—gallons	28	...
Diesel lubricating oil used—gal	1	...
Gasoline	Neg.	...
Coal used—tons	...	1.7
Kilowatt hours generated	205	...
Number of floats handled	3.4	3.4
Number of cars handled	56.1	55.9
Number of tons handled	1947	1904
Cost of fuel oil, etc	$2.54	$14.82
Operating hourly average cost		
Fuel oil, coal, etc	.208	1.15
Per car on and off floats	.045	.265
Per ton on and off floats	.0016	.0078
Cost per Kil. hour	.0124	....

Table VI—Abstract of replies from four railroads in answer to questionnaire

	Railroad A	Railroad B	Railroad C	Railroad D
Class of service (switch, flat yard, hump or road)	float and flat yard	small yard flat	small yard flat	switch
Date placed in service	10-20-25	Jan. 1926	Jan. 1926	Feb. 1926
Was purchase made in interest of smoke abatement or interest of lower operating costs?	smoke abatement	to comply with Act of Legislature	to comply with State Law	both
Load factor	unknown	10%	....	7.9
Total mileage	28842	15612	21774	29376
Total engine hours	4807	2602	3629	9792
Availability—% serviceable days	100	85	....	78
Reliability—miles per failure	7210	7806	....	2260
Estimated life of power plant	20	10	....	....
Estimated life of transmission	20	10	....	25
Rate of depreciation—per cent	3	3½	12	....
Average No. cars handled per day	unknown	61	26	480
Average No. tons handled per day	unknown	no inf.	no inf.	no inf.
Average No. 1,000 g.t.m. handled per day	unknown	no inf.	no inf.	no inf.
Costs per hour (average for total time in service)				
Fuel	.1836	.267	.212	0.29
Lubrication	.1032	.055	.031	0.07
Supplies	.0174	.0158	.027	no data
Cleaning and housing	.....	.050	.410	no data
Running repairs	.726	.2425	.518	no data
Shop repairs	.....	.289	......	no data
Depreciation and interest	1.14	2.22	2.070	unable to answer
Total cost per mile or hour	2.172	3.14	3.275	unable to answer

The report of the sub-committee on Oil-Electric Locomotives is signed by R. M. Brown (Chairman), J. H. Emerson and H. A. Hoke.

The report is signed by H. T. Bentley (chairman), Chicago & North Western; H. A. Hoke, Pennsylvania; A. Kearney, Norfolk & Western; Geo. McCormick, Southern Pacific; W. L. Bean, New York, New Haven & Hartford; C. B. Young, Chicago, Burlington & Quincy; M. F. Cox, Louisville & Nashville; W. I. Cantley, Lehigh Valley; C. E. Brooks, Canadian National Railways; G. H. Emerson, Baltimore & Ohio; H. H. Lanning, Atchison, Topeka & Santa Fe; A. H. Fetters, Union Pacific; S. Zwight, Northern Pacific; R. M. Brown, New York Central; H. M. Warden, Missouri-Kansas-Texas.

Discussion

In replying to a question, one of the members of the committee stated that the committee was not prepared to recommend any limits in fibre stresses for alloy steel. Another question was raised by one of the members as to why the committee allowed ½ in. increased size over the driving axle journal and only ¼ in. in the case of the engine truck axle. Exception was also taken to the committee's recommendation in connection with standardizing trailing truck axles. G. W. Rink (C. R. R.

of N. J.) thought that the journals should be standardized 12 in. in length for the 5-in., 6-in., 6½-in. and 7-in. axles. He stated that a 12-in. journal permitted standardizing the width of the engine truck frame and that it also provided more clearance between the equalizers and the frame. He also suggested that the committee should add another size of trailer axle, 9-in. by 16-in., stating that his road had found it necessary to use that size on account of excessive trailer loads due to the 9-ft. fireboxes.

H. H. Lanning (A. T. & S. F.), speaking for the committee, brought out the fact that practically every driving axle failure occurs in the wheel fit a short distance from the fillet. It has been the experience of more than one railroad, he said, that a driving axle which is enlarged only ¼ in. above the journal is more subject to failure than one that is enlarged ½ in. With regard to the 9-in. by 16-in. trailer axle, Mr. Lanning said that the committee feels it is desirable to keep the center of the journal axle bearing as close to the wheel as possible. If a 9-in. by 14-in. journal had been applied to the heavily-loaded trailer axle, referred to by the member, good results would have been obtained, insofar as hot bearings are concerned, and the fibre stress would have been lower in the axle at the end of the wheel fit.

The question was asked by one of the members as to whether any railroads had been experiencing any crank axle trouble on three-cylinder locomotives. Two of the members reported that they were having no trouble either with the crank axle or center main rod on three-cylinder locomotives, which are designed with the center cylinder coupled to the second driving axle, and the two outside cylinders to the third driving axle. It was reported that there were some troubles on locomotives where all three cylinders were coupled to one axle. In the discussion on the three-cylinder locomotive it was brought out that crank axles of both the built-up and solid types are used in different European countries on three-and four-cylinder locomotives, some of which favor the built-up type, while others favor the solid type,

In the discussion of boiler supports some objection was raised to the recommendations for fastening the waist sheets rigidly to the boiler. A number of members reported that this method had caused cracked shells, and that they had found the use of a waist sheet wearing plate more satisfactory.

The report was accepted and the committee continued.

Utilizing human intelligence in railroad work

Various phases of the man problem are discussed at the Mechanical Division convention

THREE papers on the general subjects of human relations and the utilization of technically trained men and of available research facilities and special knowledge from other fields, were presented during the convention. The first paper was presented by Samuel O. Dunn, editor of the Railway Age, who pointed out that a railroad actually consists of both plant and personnel which are complementary and interdependent to such a degree that there is hardly an important problem of management the solution of which does not involve changes affecting both. He referred to the evident reticence of railroad officers in exchanging and disseminating information concerning the methods used by individual railroads in solving the so-called "labor problems." He said that in the interest of the greatest efficiency and therefore, the most effective promotion of the welfare of both railways and employees, the time must come when problems of personnel and methods used in their solution will be as fully, frankly and publicly studied and discussed as other problems and methods of railway administration, construction, development and operation.

The other two papers were presented by engineers prominent in the field of railway educational activities; namely, A. A. Potter, dean of the schools of engineering, Purdue University, who presented a paper on "Trends in engineering education" and by Arthur J. Wood, professor of mechanical engineering, The Pennsylvania State College, who presented a paper entitled "A look into the future." Dean Potter discussed the various aspects and problems pertaining to both technical and non-technical education. He stressed the influential effect that the engineering profession has had in the development of national prosperity and discussed at some length the interdependence of industry and the schools of engineering.

A large part of Professor Wood's paper was devoted to a discussion of the utilization by the railroad industry of the various laboratory and experimental facilities afforded by technical institutions. He pointed out the fact that developments in the work of the Mechanical Division had arrived at the stage where it could perhaps work to advantage with other technical societies such as the American Society of Mechanical Engineers. He also advocated the establishment of a bureau of coordination and research supported by all the railroads for the purpose of handling without waste the various problems requiring research work that come before the various divisions and sections of the American Railway Association. The three papers are given in abstract.

The man problem

By Samuel O. Dunn
Editor of the Railway Age

S. O. Dunn

When we use the word "railroad" we usually refer merely to the physical plant; but a railroad actually consists of both a plant and a personnel. These two parts of a railroad are complementary and interdependent to such a degree that there is hardly an important problem of management the solution of which does not involve changes affecting both of them. The physical property and the personnel constantly react upon and determine each other.

The principal way in which improvements in the

physical plant effect economies is by reducing the amount of labor that otherwise would have to be employed. Changes in conditions of employment also often indirectly cause great changes in the physical plant. For example, formerly the wages of freight train and engine men were based upon a ten-hour day, and improvements in permanent structures and locomotives were directed mainly to making it possible to haul longer and heavier train loads between freight terminals at an average speed of ten miles an hour. About ten years ago a law was passed by the Congress of the United States making eight hours the basis of a day's pay in train and engine service. The necessity since then of paying overtime after eight hours has stimulated important changes in permanent structures and locomotives that have caused increases in both train loads and train speeds to go hand in hand and now the average speed of freight trains in the United States is twelve miles an hour.

While the physical and personnel problems of railways are thus interlocked, it is significant that, although there is much organized study and discussion of their physical problems, there is very little organized study and discussion of their personnel problems. We have a multitude of organizations representing most or all of the railways which, through committee reports and discussions at conventions, promote the improvement and better use of physical facilities; but in the reports and discussions of these organizations little or nothing is said about methods of selecting, developing, directing, promoting or compensating the personnel, and we have no organization which deals especially with personnel problems. If railway officers were as reticent about exchanging and disseminating information concerning the methods used and the results obtained in their efforts to solve other problems as they are regarding the methods used and the results obtained in their efforts to solve the so-called "labor problem," the progress made in increasing the efficiency and economy of railway operation on this continent would soon be greatly reduced.

Personnel problems a constant struggle between employee and employer

Why is there this marked difference in policies regarding railway physical problems and railway personnel problems? It is mainly due to the fact that there is constantly going on a struggle between the managements and various more or less strongly organized groups of employees, and that many managements fear that complete frankness regarding means being used to solve vital personnel problems would embarrass and weaken them in this struggle. The managements want wages and conditions of work so adjusted that they will have competent and satisfied employees and that the maximum amount of efficient labor will be obtained for each hour of work paid for. Employees want to avoid being required to exert themselves to excess, to get the highest practicable wages, to have promotions made without favoritism, to have security in their employment, and to have a voice in determining their conditions of work and wages. As thus stated, there is nothing unreasonable or incompatible in their attitudes. Nevertheless, there goes on between them the constant struggle mentioned, sometimes in a mild way over minor differences, sometimes in bitterness of spirit and in the form of strikes resulting in great losses to railways, employees and public.

Struggles between employers and employees have been occurring throughout the entire history of their relationship. But in our modern age of industrialism, with its huge aggregations of capital employing great armies of men, these struggles have assumed forms and an importance that are new. I believe, however, experience has demonstrated that under the modern industrial system there is very little real antagonism of interest between employer and employee, and that if both were not greatly, but more or less unconsciously, influenced in their thought, attitude and policies by a false economic philosophy, the age-long struggle between them would be subordinated to co-operation in furtherance of their mutual interests.

The prevalence of this false economic philosophy is partly due to the fact of common knowledge that many improvements in the plants and methods of industry temporarily reduce the number of employees required to do the work affected. There is a strong natural tendency, therefore, of those who take a short-sighted view to be antagonistic to improvements because of fear that they will result in unemployment.

The influence of Socialistic doctrines

Of even more importance is the fact that literally millions of persons are influenced in their attitude toward the relations between employers and employees by socialistic doctrines. It may shock and irritate some for a reference to socialism to be injected into a discussion of the man problem in industry which, on an occasion such as this, should be highly practical, but I do not believe we can understand the labor problem unless we consider the extent to which it is complicated by socialistic doctrine. The philosophy of modern socialism was first given to the world in the very early history of modern industrialism. Its fundamental postulate was that labor produced all wealth, but that the employer allowed the worker to earn only enough wages to get the necessities required to enable him to work until he could produce other workers, and that the employer, as a member of the capitalist class, appropriated, or at least tried to appropriate, the value of all the rest of what was produced. On this doctrine was based the further doctrine that there would be an irrepressible struggle between the capitalist class, on the one hand, and the "proletariat," on the other, until the entire system of private ownership of property should be overthrown and some system of public ownership of property and employment of all labor substituted for it.

Why should a worker, who believed the employing capitalist would get all the benefit of an increase in production per man, try to increase his productive efficiency?

It is not generally realized how extensively this economic philosophy has permeated modern literature and thought regarding the relations of employer and employee, and how it affects those relations. To many, however, including not only working men but even business men, it seems obvious that in every business there is a certain amount of income to be divided between capital and labor; that the more capital gets the less labor must get; that the more labor gets the less capital must get; and that, therefore, there is a substantial element of truth in the socialist doctrine of a necessary and continuous class conflict under our present industrial system. Anybody who reads the literature disseminated by labor organizations, including those of railway employees, will see that running through most of it is the implication that under our present industrial system most invested capital gets excessive returns; that these returns are mainly due to the unjust exploitation of labor; and that not only is it plainly to the interest of labor at all times to try to improve its working conditions and wages to the greatest extent possible at the cost of a reduction in the return received by capital, but that it is

by no means plainly to the interest of labor to help increase the productive efficiency of industry by doing the most and best work it can in each hour for which it is paid. We have, therefore, constantly presented the spectacle of labor trying to get its wages increased, and at the same time trying to get the work it has to do for them per hour or day limited or reduced.

Workers, not owners, receive greatest benefit from increased output

Now, it is my belief, based upon what I take to be incontrovertible evidence, that in the long run on the railroads and in every other large scale industry it never has been and never will be the owners of capital and the managers of industry, but that it always has been and always will be those who work for wages, who have got and will get the great bulk of all the tangible and intangible benefits resulting from every increase in the output of industry per man-hour of labor employed and paid for, and that, therefore, it is the employee and not the employer class who should be most anxious to see efficiency in every branch of production increased by every means possible. If this is true, and labor can and shall be convinced it is true, the solution of the problem of getting the co-operation of labor in adopting and carrying out innumerable methods of increasing efficiency in all branches of industry, including that of transportation, will be made much simpler and easier.

The increase in the total operating revenues of the railways per employee between 1906 and 1926 was from $1,540 to $3,571, or 132 per cent. This was due to the average increase of 58 per cent in the output of transportation per employee and to average advances in freight and passenger rates of 47 per cent. Now, how did the employees of the railways and the capital invested in them share between them the benefits resulting from the increase in total earnings due to both increased output and advance in rates? If the employees had shared only in proportion to the increase in output per employee and the advances in the rates the increase in their average annual compensation would have been 132 per cent, but in fact the average annual compensation per employee increased from $596 in 1906 to $1,656 in 1926, or 177 per cent. Net operating income is the return earned on the capital invested in the industry, and it amounted in 1906 to $480 per employee. If it had increased during the last twenty years as much in proportion per employee as did the average wage paid, or 177 per cent, it would have amounted in 1926 to $1,330 per employee. If it had increased only as much in proportion as the average operating revenues per employee, or 132 per cent, it would have amounted in 1926 to $1,108 per employee. It actually was in 1926 only $682 per employee, an increase since 1906 of only 42 per cent. Since the increase in investment *per employee* was 61 per cent and the increase in net operating income *per employee* only 42 per cent, it follows that there was a decline in the average return earned upon each dollar of capital invested. Average return upon investment in 1906 was 5.9 per cent, and in 1926 only 5.3 per cent.

These facts show beyond all question that during the last twenty years the employees of the railways have received far greater benefits from the improvements in the properties and in their operation than those who, by the investment of capital in them, have made these improvements possible. Twenty years ago the employees as a whole received an income from the industry 24 per cent greater than the income received by capital, while last year the employees received 140 per cent more than capital. Probably in most other industries the increase in the incomes of employees has not been so much greater in proportion than the increase in the income of capital as it has been in the railroad industry, because the railways have been subject to a special form of regulation directed mainly at limiting the return received by the capital invested in them. But in practically all other industries wages have increased much more in proportion than the income from invested capital. In other words, the facts demonstrate that under our present industrial system it is the employee, not the employing class, that gets the lion's share of the increases in income and purchasing power resulting from large and wise investment of capital, good management and sane co-operation between employers and employees to intensify industrial efficiency. During most of the period reviewed the difficulty of raising capital for the railroad industry constantly increased because of excessively restrictive regulation of the return upon it. Undoubtedly if the percentage of return allowed to be earned had been larger the amount of capital invested would have been larger, resulting in improvements in facilities that would have effected still greater savings of labor, fuel and materials, thereby making possible even higher wages for employees or lower rates for the public.

Safety and improved working conditions effected by increased capital investment

In addition to the increase in the purchasing power of their wages and reductions in their hours of work, railway employees have been benefited in other ways by the improvements in the plants and in operation. Their work has been made safer. The amount of physical exertion required to do their work has been reduced in many ways. Many improvements have been effected partly or wholly by the investment of capital, and, while most of them have been introduced to increase efficiency and save expenses, they have had incidentally the effect of reducing the amount of back-breaking labor required from employees and of making their work more pleasant and healthful.

It is hardly necessary to say that a large production per employee in the railway and other industries does not result in proportionately high, or even proportionately higher, wages merely because of a generous disposition of employers to pay high wages. Nor are advances in wages mainly due to the organized pressure of employees for them, because without increases in average output per employee there would soon be no source from which the means of paying higher "real wages"—that is, wages of greater purchasing power—could be derived. Increased production per employee results in increased average real wages per employee mainly because of the operation of economic laws over which neither employers nor employees have much influence. Increased production will not increase the prosperity of industry without increased consumption of the products of industry, and since those who work for wages constitute the largest single class of consumers, they must, if industry is to prosper, be paid wages high enough to enable them to increase their consumption as production increases. Obviously, however, high production must precede and thereby make possible the wages of greater purchasing power required to enable the employee class to become larger buyers and consumers of necessaries, comforts and luxuries. It is the large average purchases and consumption per person to which we refer when we say that the standard of living in Canada and the United States is the highest in the world, and it should be obvious that this high

average consumption is made possible only by high average production.

I have at such length emphasized and elaborated upon the economic effects upon the working class of increases in industrial efficiency because the most serious obstacle always encountered in almost every effort to increase railroad efficiency and economy has been an antagonistic attitude of employees due to a widespread belief, more or less clearly held and expressed, that while increases in efficiency would be to the advantage of the railways, they would not benefit, and probably would be contrary to the interests of the employees. The most effective means ever used to enhance the economy of operation has been that of increasing ton-miles per train-hour through improvements in roadway, tracks, signals, cars and locomotives that have made it possible to increase the loads of freight trains and to move them more rapidly. This, of course, reduces the number of trains, of locomotives and of employees that otherwise would be required to handle traffic. Employees' organizations resort to various means to prevent these improvements from producing their natural results. For example, in train service wages are based on miles as well as hours, and in a large part of the country they effectively insist upon a limitation of the number of miles that a locomotive engineer can make in a month, the purpose being to divide the work among an unnecessarily large number of men. Among the effects are to restrict maximum and average monthly and annual wage earnings, and thereby strengthen demands for increased hourly and mileage rates of pay. The trainmen's organization has succeeded in many states in getting laws passed requiring the railways to employ an unnecessary number of men in the crews of long trains, and is still engaged in trying to get such laws passed, or even laws arbitrarily limiting the length of trains. Such laws tend, of course, to defeat the main purpose of all improvements made in locomotives and other facilities to enable freight to be handled in larger trainloads, which is to increase the amount of transportation produced with a given amount of labor.

The effect of seniority

Many other illustrations of the same general character might be mentioned. The best possible organization of industry is essential to the highest practicable efficiency, and good organization consists largely or mainly of putting in every position, whether in the lower ranks of the employees or the higher ranks of the officers, the man best qualified to perform the duties of that position. On all railways in some branches of the service and on many railways in most branches of it, however, representatives of the employees strongly insist upon promotions according to seniority. While usually promotion by seniority is in the interest of efficiency, because of the longer training and experience of the senior man, this is so often not the case, because of wide differences in the natural initiative, ability and energy of men, that the rigid adherence to seniority favored by many organizations of employees is plainly contrary to efficiency. It is significant that in the selection of officers of their own organizations employees do not adhere to seniority with the strictness with which they try to get the railways to adhere to it. The prevalence of seniority rules now presents one of the greatest difficulties encountered in putting men of good education and natural ability in supervisory positions while they are still young enough to get the training and experience they should have to fit them for higher official positions.

One of the strongest incentives that can be given men to work with maximum efficiency is that of paying them in proportion to the amount and character of the work they do. This incentive is given in many industries by payment on piece work bases of various kinds. The amount of piece work done in the railroad industry is relatively very small. The amount of wages paid to all employees of Class I railroads in the United States last year—excluding officials—was $2,859,000,000, and of this only about $80,000,000, or less than 3 per cent, was for piece work. It seems significant that the average hourly earnings of piece work employees were 83.7 cents while the average hourly earnings of all employees paid on an hourly basis were 58.7 cents. There are some valid objections to piece work, but no doubt the principal reason that prevents it from being more extensively used in the railroad industry is one that is not valid, namely, that it tends to reduce the number of employees required to do a given amount of work. No doubt it does tend to have this effect, but the belief that it is, therefore, inimical to employees is but another illustration of the widely prevalent but economically unsound belief that industrial efficiency is advantageous to capital but not advantageous to labor.

Almost every increase in railway efficiency that has been accomplished has reduced the number of hours of human labor required to produce a given number of ton-miles and passenger-miles, but this has never actually resulted, except temporarily, in a reduction of the total number of employees. There was a large increase in their number during and immediately following the war owing to the general introduction of the eight-hour day and other causes, and a correspondingly large reduction as a result of the industrial depression and the increase in the efficiency of operation which followed the return of the railways to private management. In 1926, however, the number of employees of the Class I railways of the United States was larger than in any other year in history, excepting the war years and in 1923, when it was affected by the results of the shop employees' strike of 1922. Excepting under abnormal conditions increases in railway output per employee, resulting from more efficient operation, have been offset by increases in the total amount of traffic to be handled.

What does this discussion suggest as to the means which should be adopted better to solve the vitally important man problem as it is presented in much the same form on our railroads and in all other industries in which men work for wages?

Now, the relations between a railway and its employees are primarily business relations. The railway hires every man on its pay roll for its own business purposes, and every man on the pay roll hires to it to get as much wages as he can. Therefore, when the management proposes to the employees that they shall do certain things to increase efficiency it is reasonably to be expected that the employees will want to know how they will be benefited by doing these things, just as when the employees ask for higher wages they should reasonably expect that the managements will ask what the employees are doing or intend to do, or what conditions exist, to justify paying them more. There is a valid reason that the managements can always give why employees should support them in every practicable way in increasing efficiency, and this is the one I have tried to illustrate by the citation of facts of railway economic history—namely, that in the long run much the greater part of the benefits of every form of increased efficiency in transportation and production goes to the workers in the form of better and safer working conditions and of wages that will increase their purchasing power. It is because labor generally does not know this that we so

often find it harmfully antagonistic to more efficient machinery and methods.

The true definition of railway efficiency from the standpoint of both management and employees is, the largest practicable production of ton-miles and passenger-miles in proportion to the number of man-hours and of tons of fuel and materials used in rendering railway service. Broadly speaking, there are two ways of increasing efficiency as thus defined. The first is by the investment of capital in the innumerable ways by which labor, fuel and materials can be saved. In order that all the capital may be raised that can be effectively employed for these purposes it is necessary that each railway shall earn an amount of net return that will make it an attractive concern in which to invest capital and in their own selfish interest the employees should always support the managements in their efforts to keep total earnings high enough and operating expenses and taxes low enough to produce an adequate net return on capital. Capital consists simply of the tools with which the personnel works, whether they be small tools in shops or such great tools as locomotives. The better these tools are the larger, if they are skillfully used, will be the output of transportation per employee, and if freight and passenger rates are reasonably regulated, the larger also the total railway earnings per employee out of which the average wage per employee must be paid.

The second important means of increasing efficiency is that of so organizing the personnel, and securing such co-operation between all the classes and individuals composing it, that the physical facilities provided by capital will be used with the greatest practicable skill.

The needed organization and co-operation of the entire personnel can never be fully attained until labor in general has the right idea regarding its own true interest. It will never have this right idea until it is given it by education. The resistance that has been offered in the past, and is offered now, to so many efforts of management to increase efficiency through improvements in plant, promotion according to merit and the payment of wages according to the work done, will continue. Great exertions will have to be made to overcome it, and it will be overcome with only partial success as long as so many working men continue to believe that improvements in plant, in organizations and in methods are intended and adapted mainly or solely to enabling capital to get more profits by making part of the employees do more work, and throwing the rest out of their jobs.

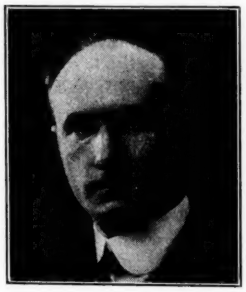
Throughout the United States and Canada railway managements are experimenting more or less with plans of co-operating with both standard labor unions and so-called "company unions," with employee representation, with employee ownership of securities, with various methods of educating employees, with different schemes of piece work, of selection and promotion of employees, and so on. They are, however, reticent about making many of these plans public except in broad outline, and especially reticent about discussing in any detail the methods used and the results obtained. This reticence, as I have already intimated, is plainly due to apprehension regarding the possible results of talking too much about efforts being made to solve the man problem. But, if as I believe is true, most of them tend and are intended to promote the interests not only of the railways, but even to a greater extent those of the employees, why would it not be desirable to have the facts about them and their results publicly presented and compared in order that methods shown to be producing the best results might have a better chance to become widely known, understood and adopted?

It seems to me that in the interest of the greatest efficiency, and therefore, the most effective promotion of the welfare of both railways and employees, the time must come when problems of personnel and methods used in their solution will be as fully, frankly and publicly studied and discussed as other problems and methods of railway administration, construction, development and operation.

Trends in engineering education

By A. A. Potter

Dean of the schools of engineering, Purdue University, Lafayette, Ind.



A. A. Potter

There are many people who are constantly finding fault with our type of civilization and are singing the glories of the good old days. These critics of our times find nothing to commend about a civilization which by releasing an enormous amount of mechanical power to supplement human labor has produced comfortable modes of living for everybody. They find little to praise in a civilization in which there is so little difference between the rich and the poor as far as the food they eat, the clothes they wear, the convenience of their homes, the educational advantages they enjoy, or the general conditions of life which tend to raise all normal minds to a common level of happiness. The contrasts of poverty in the good old days may have been more inspiring to the poet, but the lack of inequality among civilized people and their comfortable living is much more conducive to human welfare.

Engineering strives to provide better and easier ways of satisfying human needs. During the last 25 years science and engineering have richly contributed to human welfare by elevating social conditions and improving standards of living. If our people are more prosperous, more comfortable, and more happy because of the abridgement of distance through modern transportation facilities; because of the use of mechanical power and machine-made products; because of the ease of communicating with others by means of the telegraph, telephone and radio; because of the development of the electric light, artificial gas, the X-ray, the moving pictures and the talking machine; because of the adequate water supply, safer sanitary arrangements, better buildings, streets and roads—if for these reasons life is now better worth the living than ever before—it is because scientists, inventors, railroad builders and engineers have for a generation been working quietly, persistently, and systematically to confer these benefits on mankind as their contribution to the economic progress of human society.

Are there any factors which are contributing more to human welfare than the railroads? Who should receive the greater credit for the stability of the United States and the Canadian governments—the politicians, the lawmakers, or the railroad builders? Does the average person appreciate his indebtedness to engineering of which railroading is an important part? Those who are responsible for our prosperity are keeping silent while the critics of our type of civilization, who care little about true values, are minimizing the true worth and work of those who are responsible for the development of our railroads, utilities, factories and public works.

Engineering as it affects national prosperity

Competent American and foreign investigators attribute our industrial prosperity in the main to four causes:

1—Higher level of intelligence throughout American industry as compared with industries of other countries.

2—Large use of power and of machinery to increase the effectiveness of human labor.

Over seven mechanical horse power are available per capita of the United States population, the equivalent of at least one hundred slaves. This enormous strength of ours in the form of mechanical power has stimulated industrial development to such a degree that the American worker turns out more goods, commands higher wages and lives better than any worker in the world.

Engineering demonstrates that the most efficient way to utilize man's capacity for work is to allow him by his skill and knowl-

edge to direct and control machinery by which work is performed.

3—Low cost of production of manufactured goods in large quantities, leading to an abundant supply of goods at low prices. Modern production methods are the application of engineering to manufacturing problems. The science of management is a branch of engineering and the elimination of strikes in industry during recent years has been attributed by many to the engineer-manager.

4—High wages, causing a large public demand for manufactured products.

These four conditions are to a large measure the results of popular education and the work of the engineer. The American engineer is concerned not only with materials, methods and machines, but also with management, men, money and business policies.

Industry and engineering colleges are interdependent

The rapid growth in the number and in the enrollment of the engineering colleges in the United States and of Canada during recent years is in part an indication that there has been public approval of the type of education offered by these institutions. Conditions on this continent have also been particularly favorable to engineering education because of our unusual natural resources; also because of the rapid growth of our industries and public utilities, which are dependent upon men who are technically trained.

You, the railroad men of this country, whether you received your education through shop apprenticeship or by special schooling, are engineers, in the proper sense of the word. Your contact at all times with technological problems enables you to appreciate the value of the engineering college as a time saving device for those who are expecting to devote their lives to railroading, manufacturing or other careers which require special technical knowledge.

There is a greater realization at the present than ever before of the value of technical education. The importance attached to engineering training not only for technical positions but also for administrative and executive posts is demonstrated by the fact that practically all of the major executives of the electrical manufacturing industries and of the electric utilities are technically trained engineers. The experiences of manufacturers and of electric utilities with college trained engineers have resulted in a constantly increasing demand for the product of engineering colleges.

With the increasing complexity of modern railroads, their constantly growing dependence upon technological improvement and new leadership, they are bound to have an increasingly close and direct interest in the product of the engineering colleges.

Are the railroads of the United States, Canada and Mexico attracting their share of engineering college graduates? If not it may be well for the American Railway Association to study the experiences of manufacturers and of electric utilities in recruiting, training and advancing college trained engineers, so that a plan may be perfected whereby the railroads of this country may be in a position to attract the most gifted and the best trained of the youth of this generation.

Engineering education in the United States and Canada

About 160 colleges and universities are giving in the United States and Canada undergraduate engineering instruction to about 60,000 students. Contrary to the general impression the curricula of these engineering colleges *are not specialized.* Our students receive during their four year undergraduate engineering course at least two years of work which would be acceptable toward a degree in practically any college of arts and sciences. The professional training of the engineer must be gained largely in the field, as engineering service does not conform closely to definite types and it is impossible to foretell the intellectual requirements which will be demanded of the engineering graduate in practice. Collegiate curricula in engineering are based primarily on the principles of science and mathematics. They are intended to precede and supplement but not to supplant practical experience in industry. Engineering colleges do not claim to be able to graduate men who are competent, without a long period of practical experience, to run a railroad or to hold down any other important technical or executive position. The testimony of those who have been employing engineering college graduates gives ample evidence to the soundness of engineering education in its general plan.

The median earnings of engineering graduates are as follows: 5 years after graduation \$3,000, 10 years \$4,000, 15 years \$5,000, 20 years \$6,000. These figures show very clearly that the engineering college graduate does not expect large compensation until he has established himself and has learned the practical details of the business he has chosen to enter.

The facilities for engineering instruction of collegiate grade are more than adequate. In fact it is doubtful as to whether the United States and Canada need 160 engineering colleges to meet the present requirements for the training of engineers of the professional grade.

Non-collegiate technical instruction

Our present facilities for the non-collegiate type of technical instruction are extremely meager and are absolutely inadequate for the proper training of men for the junior technical and supervisory positions of industry. Neither are our facilities adequate for the preparation of unskilled workers.

Many are forced to leave school at an early age. The preparation of these young people for useful service to industry and for good citizenship is of great importance to the public. Modern industry has been compared to a building of several stories with no inside or outside elevator or stairs. The unskilled workers find employment on the lowest story, the next two stories are occupied by semi-skilled and skilled workers, while the executives occupy the top story of the industrial structure. A comprehensive system of technical education should prepare the worker so that he can enter from the outside any of the stories of the industrial structure: it should also provide part-time courses, short-time courses, continuation schools and correspondence instruction for the worker now in industry so that he can climb from one place to another as rapidly as his natural ability and ambition will *permit.*

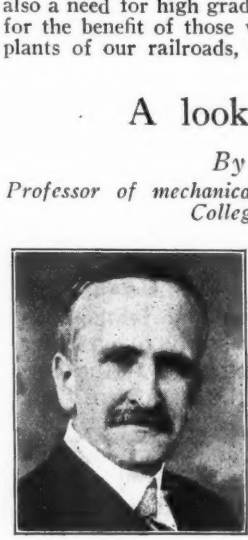
Some of the Continental European countries have several well defined levels of technical education. At the top are the technical universities, which are similar to the best engineering colleges of the United States and Canada and which admit only those who have completed the full program of secondary education. At the middle of the scale are numerous technicums which admit those who have continued their studies to the age of 14, and which train for the junior technical and supervisory positions in industry. At the bottom of the scale are apprentice schools for skilled workers.

We need on this continent more technical schools of a distinct non-collegiate type, briefer, more intensive and more specialized than the programs of engineering colleges. There is also a need for high grade technical instruction by correspondence for the benefit of those who are now employed in the shops and plants of our railroads, industries and utilities.

A look into the future

By Arthur J. Wood

Professor of mechanical engineering, The Pennsylvania State College, State College, Pa.



Arthur J. Wood

The major problem of today is to haul, at allowable high speeds, one ton, one mile at the lowest possible cost. With increasing operating costs, the time factor became of the greatest importance. The problem of tomorrow will be a more complex one, involving in addition to the major problem of today, motor competition on the highways, more exacting requirements for comfort and convenience due to our higher average standards of living, and more clearly defined supervisory and technical functions.

The most serious problem that recently faced the railroads in this country has been the increasing cost of operation, but even this is being stabilized. The cost consists largely of labor, fuel, materials, and maintenance and these are closely related one with the other. Since the first three predominate, the problem reduces to increasing the output of the individual, to using a larger percentage of the available energy of fuel and to obtaining materials which will stand the gaff, thus lowering the maintenance.

Materials and maintenance costs may be so adjusted that an increase in the cost of the first may mean a decrease in the cost of the second, as for example the selection and application of the best kind of metal to be used in axles, boiler plates, side rods and stay bolts.

Another illustration relates to the lubrication of journal boxes. In 1894, a committee of the Master Car Builders' Association reported an estimate of one hot box detention for every 20,000 car miles operated and that the cost was 24 cents per 1,000 miles. In 1916, a certain railroad frequently had one hot box detention for each 30,000 miles. During March and April, 1927, this road showed over 700,000 car miles per hot box detention in

passenger service. The chief chemist states: "The reduction of cost since 1894 is largely due to the fact that at that time compounded oils were generally used, and at the present time we are using petroleum oils which are not compounded. Much of our reduction in the number of detentions has been due to carefully selecting oils to exclude those which contained objectionable tarry matter, and we have also materially reduced the viscosity of oils used, thereby diminishing the internal friction and running temperatures of the bearings." The extra cost in this case was not in the material itself, but in the investigations which led to the proper use of the most desirable lubricant.

The economic adjustment between materials and maintenance offers one of the greatest possibilities for the technical staff.

The problem stated

A new factor has recently entered into the technical functions of the engineer. Twenty-five years ago, the supply industry held a relatively unimportant place in the development of the mechanical requirements of the railroads. The problems confronting the locomotive and car departments were relatively simple. Today, the supply industry has grown to enormous proportions and in addition to developing its engineering personnel from outside sources, approximately 43 per cent* of the executive technical officers and the supply staffs of railway supply concerns, appointed or promoted since 1919, have been recruited from the mechanical departments of the Class I railroads.

With rapid developments, there has come a tremendous increase in the complexity of both the locomotive and car problems and the questions now confronting the railroad mechanical officers in making decisions on new equipment are often related to branches of engineering, somewhat remote from the direct problem of motive power. I refer to such subjects as heating and ventilation, heat transmission, lubrication, chemistry of combustion, corrosion and lighting.

This general situation also has a direct bearing on the question of the railroads and the colleges. It is my observation that four graduates in mechanical engineering go with railroad supply companies to one who enters the service of the railroads.

As in the past, there is a "romance of the rail" but this does not mean quite the same as it did earlier in this century. Other industries also hold out enticements for the oncoming generation. Contrary to a general belief, the curve of average earnings of mechanical engineers employed by railroads is above that for industries at large;† but, with few exceptions, the railroads have not entered the same as has other industries into the competition for obtaining the best product of the engineering schools. It is my prediction that if you aim to secure and hold the desirable technical graduates you must recast your methods of recruiting, training and placement of these men. The proper selection of promising recruits is as important as the selection of materials, and is a more difficult task. This whole question must enter into the future of the railroads, but let me assure you that we of the colleges share with you the responsibilities in this matter. The utilization of the college trained man is a subject to which the Mechanical Division may well afford to give more attention.

Technical societies

During the period of the growth of the railroad supply industry, technical societies have taken a significant place in furthering engineering progress. The fields of electric power, refrigeration, heating and ventilation, gas power, chemical engineering, hydraulics, materials of construction, machine tools, management, foundry practice, and many others are well organized through their respective societies. In the main, their problems are also yours, for railroad engineering comprehends a vast field of endeavor.

Of all the societies, the American Society of Mechanical Engineers probably comes the nearest to your interests and its Railroad Division, above all others, ought to have your co-operation. Its policy is to confine its work to the highly technical problems of railroad mechanical engineering and should be an incentive and assistance to the Mechanical Division of the A. R. A., rather than divert any of its functions or activities.

Other facilities

Again, there have been developed expensive and excellent laboratory facilities in our engineering schools and most of these are in active service but three-fourths of the time each year. The elaborate and classic tests instigated and supported by the Mechanical Division and now in progress at Purdue University, is a forward step of great significance.

While the first and most important job of a university is to teach, there are many institutions that have developed special facilities along certain lines. One has worked for years in furthering the science of heat transmission, another has specialized in internal combustion engines, a number have outstanding facilities for metallurgical, heat treating and allied fields, while others have become recognized in the field of combustion, heating and ventilating and industrial chemistry. There may soon come a time when these organized agencies may serve the railroads as never before.

The engineering experiment stations, some 20 in number and manned by some of the best technical men in the country, are undertaking practical research problems, as important to the railroad engineer as to industry at large. Usually, problems dealing with fundamental research are carried on by these state supported laboratories, but many industrial companies co-operate in tests on some of the work having a commercial bearing. The University of Illinois has issued 160 bulletins from its station, of which 10 or more are on railroad mechanical subjects. The Engineering Experiment Station at The Pennsylvania State College has expended in 15 years at least $100,000 in the very practical subject of heat transmission. Many of the stations are equipped to carry out work in special fields of engineering.

Car heating is an important subject, but notwithstanding recent improvements the data available are neither satisfactory nor conclusive. The whole field should be reviewed in the light of economy and of comfort to passengers, and in this, as in most of the new developments, the railroad officers and the railroad supply interests must work together in the spirit of "give and take." The questions raised bring out the interrelation of our engineering problems, a point which I aim to emphasize in this paper. They also indicate that more experimental work is needed. The Research Laboratory of the American Society of Heating and Ventilating Engineers is working on many problems directly related to your interests.

Other problems

Although appearing in a different aspect, questions of the same nature remain unanswered for some of the preventable heat losses in the locomotive and in refrigerator cars. As a further illustration of interest in health and comfort, mention may be made that a research laboratory, not connected with a railroad, was recently asked to advise on methods of cooling passenger cars during the times of excessive heat. The mere suggestion of a Pullman car kept at 72 deg. F. in the summer season, with the windows closed keeping out noise and dirt, brings satisfaction to the traveler. Surely the engineer has a duty to perform in addition to the development and care of material things, wonderful as they are. I expect to see the day when practically all dining cars will have their individual mechanical refrigerators and when refrigerator cars will, for the most part, be cooled by mechanical means, using an improved compressor system, or working on the absorption principle.

Improvements and refinements of this character are directly related to the question of rates charged, but experience is somewhat convincing that the people will pay for safeguards to their health.

Railroad officers fully appreciate the importance of such problems as those cited in this paper and of their application to the broad field of transportation. Would it not be of direct benefit to the greatest industry in this country to provide a central bureau of study and investigation where problems of common concern could be reviewed, analyzed and reported upon?

The demands of the present call for a new angle of approach in the solution of many problems. The Master Mechanics and Master Car Builders Associations have rendered an invaluable service, and the Mechanical Division will continue to establish standards and recommended practice. The Bureau of Railway Economics is also filling a real need, but I fail to find a clearing house for the review of the more purely technical railroad mechanical and electrical problems.

Looking to the future, and as a step toward economy of time, effort and money, would it not be desirable to establish and maintain a bureau of co-ordination for technical problems? To such a bureau might also be assigned the task of formulating necessary or desirable recommendations as they affect all railroads in the selection, training and placement of engineering graduates.

The future of motive power

Turn, if you will, to a topic which is uppermost in our minds—the future of motive power. Many agree that the greatest single possibility lies along the lines of new developments in the utilization of fuel. A lower average rate of coal burned per square foot of grate giving increased capacity and made possible in part by the four-wheel trailing truck, the correct proportioning of grate area and firebox volume, the extended application of water tube boilers, pre-heating air for combustion, application of induced draft, thus reducing the back pressure in the cylinders, the use of higher steam temperatures, which will introduce new

*From report presented by the Sub-Committee on Professional Service of the Railroad Division, at the annual meeting of the American Society of Mechanical Engineers, December 7, 1926.

†See *Railway Mechanical Engineer*, February, page 93.

problems in superheat, reduction of losses in heat exchange to the cylinder walls, and new developments in design of feed-water heaters for locomotives are some of the problems before us. As in stationary practice, the boiler development has usually lagged behind the engine development. In these questions, capacity vs. economy call for a more extended study.

Both mechanical and air atomization of liquid fuel are being developed to give a better and a more positive control of combustion. If, by this means, it becomes possible to liberate more heat without exceeding the present temperatures, the percentage of jacket loss may be materially reduced. This should lead to a more powerful engine for the same weight, without a decrease in the thermal efficiency of the actual engine. Moreover, it seems increasingly probable that solid fuel, such as pulverized coal may be successfully adapted to the Diesel engine with consequent material reduction in fuel costs.

With the present metallurgical developments, the upper limit for the steam engine seems to be one of temperature, approximately 750 deg. F. This may be reached by high pressure and moderate superheat, or by lower pressure and higher superheat. Reheating and regenerative cycles offer thermodynamic possibilities which have not been fully investigated. But taking advantage of all these refinements, the present margin for improvements is relatively small, probably in the neighborhood of 10 per cent over the present efficiency, which means an increase to only 10 per cent over-all efficiency, if we can now attain even as high as 9 per cent. There are limits in refinements beyond which we should not attempt to go; other possibilities, as savings by roller bearings, better steam heating, etc., should be given more attention.

Modernization must not be carried to the extreme and to the detriment of other improvements. It takes men of experience, sound training and clear vision to decide wisely many of these questions. The bigger the organization the more is the call for executive ability at the top; executive ability and a research mind are not commonly found in the same individual. All this takes us back to my reference to the complexity of the problems before the mechanical staff of the railroads.

Influence on design by locomotive test plants

The great advance in our industrial progress in the last 25 years can be traced directly to the increasing interest in science and research, which involves accurate methods of testing. A striking illustration, as applied to locomotive development, is found in the influence exerted by locomotive test plants, and without which it is safe to state that findings as noted below could not have been obtained with any degree of assurance.

Among other results, the Purdue test plant gave a new meaning to the factors limiting indicated horsepower and rates of combustion and for the first time it brought out the relation between cut-off and steam consumption as influenced by speed. It was also shown that the draft producing action of the exhaust steam was independent of the intermittency of the exhaust, the essential factor in the suction produced being the quantity of steam exhausted. Lawford H. Fry has pointed out that this is often overlooked, particularly when the claim is made that a multi-cylinder locomotive gives a more efficient exhaust action. With the results now available for three-cylinder locomotives, would it not be desirable to recheck the effect of intermittency of exhaust?

The Pennsylvania Railroad locomotive testing plant, originally located at the St. Louis Exposition, and since 1905 at Altoona, has been constantly accumulating a veritable gold mine of information, which has made possible continued improvements in design. A few of the many results may be noted: The determination of maximum rate of evaporation per hour per square foot of fire area, diameter of piston valves for cylinders up to 30 in. in diameter, the greatly increased rate of unit evaporation of short tubes over long tubes, the quantity of water evaporated for one square foot of free air space through the fuel bed support, effect of varying amounts of superheat on steam consumption, advantage gained in boiler efficiency by the use of fire-brick arch when high volatile coal is burned, losses as determined by a heat balance from tests, heat absorbed by the superheater as compared with that absorbed by the water heating surface, losses in steam pressure between boiler and cylinder, most economical point of cut-off, and economy effected by feed-water heaters.

The list of findings might be greatly extended, but is sufficient to remind us of results definitely accomplished by these pioneer plants. It indicates one of the means by which the steam locomotive has met the challenge of competition during the past 20 years; but more than this, it suggests the necessity of more research and testing all along the line, lest others take from you the business, and with it the willingness of the people to back improvements and continue reconstruction.

Looking beyond the present, let me urge you to get behind the men who are doing development work and turn over to them the facilities which they must have to go on with their labors. It is no longer a question if the railroads can afford to do this. Can they afford *not* to do it?

In view of the present situation, as briefly outlined in this paper, but with no thought of slowing up the work which is being undertaken by individual companies, I see a real need for the establishment of a Bureau of Investigation which would be supported by all railroads. It might properly be combined with the suggestion noted earlier in this address, and the two function as a "Bureau of Co-ordination and Investigation." This general idea was recently submitted to a leading member of the Mechanical Division, who expressed himself in the following words concerning the proposal:

"The establishment of a bureau of research supported by all railroads and properly supervised so that the results of their efforts would be based entirely on improvement would, in my opinion, definitely cheapen transportation, and improve service, as well as be most desirable. Such action would result in co-ordinating the best thought on any subject and at the same time make it possible to gain expressions from institutions such as yours, which have specialized in certain research activities, so that economy of expenditures could be preserved over what would obtain if a central bureau as established demanding facilities for making appropriate research work in all branches of railroad activities."

For years the National Research Council has served many industries by substantially just such a plan. As a member of the executive committee of one of its divisions, I am acquainted with the results obtained during the past few years in the field of heat transmission and am confident that the art would not be as far advanced or the service rendered be as extended had not this work been centralized through the co-ordinating agency of the council.

Reviewing with you some of the aspects of a new economic era in railroading, I would close by reminding the Mechanical Division that the big problem the engineer must solve is how to meet the inevitable demands that will be placed against his ability tomorrow. This problem is facing us. What will be *your* answer to it? I have ventured to suggest some of the means at hand which should aid in a satisfactory solution.

Freight cars repaired by the progressive system

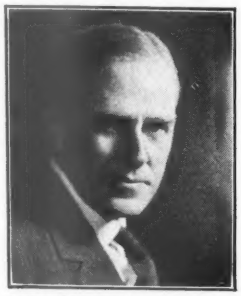
Questionnaire sent to railroads furnished committee with data on which are based specific recommendations

In submitting this year's report at the Mechanical Division Convention of the American Railway Association, the Committee on Shops and Engine Terminals has placed on record a suggested design for freight car repair shops, which, while not adaptable to all conditions, lays down enough of the fundamental requirements of such design to serve as a valuable guide to those planning new facilities. The findings of the committee were based on a questionnaire sent to the principal railroads of the United States and Canada to which replies were received from 64 railroads representing 75 per cent of the total number of cars owned by all of the railroads in the two countries.

Among other things, the report established the follow-

ing facts: Most railroads are giving heavy repairs to one series of cars at a time; the total number of positions for steel cars are usually nine and for composite or wood cars, seven; there is a considerable difference of opinion as to the relative merits of the double-end shop and the return-through shop. The report also includes supplemental drawings to the car shop layout shown in the 1926 report in which provision has been made for a gap riveter and riveting pit in the erecting bay.

Report on design of shops and engine terminals



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W. A. Callison
Chairman

The report which your committee submits this year is based upon a resolution that was passed at our 1926 convention, in connection with this committee's report to the convention, to-wit:

(*Moved*)—the report of the Committee on Design of Shops and Engine Terminals be accepted and the committee be continued with instructions that consideration be given a system and a layout of shop that will insure a car being taken from revenue service in bad order, and returned to service in good condition in the least time and at the least cost.

The methods of repairing cars must vary necessarily to meet the different types of construction and, also, usually conform to a program which appears best to the shop supervision, or the railroad management. Therefore, shop methods in the repairing of cars have not been and probably never will be standardized in every particular. Certain details of repairs, however, such as wheel shop practices, follow the same general methods in nearly all shops. This has been brought about, largely, by conforming shop methods to meet the standards set, from time to time, by the A. R. A. Committee, and also by improvements in machine tool construction, which have been standardized by practicaly all builders of wheel shop machinery.

There is now in use a method of repairing cars which has commanded a great deal of attention in recent years, and that is the so-called "progressive system." This system has been mentioned in previous reports of this committee—in 1925 in connection with layout for a passenger car repair plant, and in 1926 when a layout for a freight car repair plant was submitted. The progressive system is now quite common in railroad shops throughout the country, but it is not operated in identically the same manner in all shops. To gain a better idea of how extensive the progressive system has been adopted, how it is operated on the several railroads, and of the results that are being obtained, the committee sent out a questionnaire to the principal railroads of the United States, and Canada. Replies were received from 64 railroads, owning 2,036,855 cars, or 75 per cent of the total number of cars owned by all of the railroads in these two countries.

The replies indicate a lively interest in the subject, and contain a great deal of information. We are giving below the questions asked, and following same a summary of the replies:

1—Do you use the progressive system in any of your car repair plants? If so, do you repair at one time a comparatively large number of cars of one series, or do you take in cars regardless of series or class?

Replies indicate that of the 64 railroads answering the questionnaire, 28 railroads, representing 1,364,573 cars, stated they were using the progressive system in some form; while 36 roads owning 672,282 cars, stated they were not using such a system. Nearly all replies reported that to use the progressive system successfully it is necessary to take in cars by series—that is, to put through the shop at one time a considerable number of cars of the same general series, and in about the same general condition with respect to needed repairs.

2—If progressive repair system is used, advise:
(a) Class of repairs—heavy—extraordinary, probably involving betterments.
(b) Class of cars repaired—wood, steel composite.

A majority of the replies state that only heavy and, (or) extraordinary repairs are undertaken by the progressive system. Steel cars predominate in the total number of cars handled by this method: composite cars next in number; while comparatively few wood cars are repaired with the progressive system.

(c) Give program of moving car through shop, stating: Number of positions for each class of car worked; operations performed in each position; number of men in each position—mechanics, helpers and laborers, and time in minutes at each position.
(d) Show plan of shop for repairing cars as per (c) indicating size of building, track and machinery, layout, cranes and erecting runways, and other auxiliaries.
(e) Normal output different class of cars working one shift—8 hours.
(f) State method of wage payment—day work or piece work.

A review of the answers to these inquiries show that while practices in the several shops differ in detail yet there is more or less uniformity in the method of moving the cars through the shop, and from the data submitted we are attempting to outline briefly below a program which is a sort of composite of all of the replies received.

Total number of positions—for all steel cars usually nine, and for composite or wood cars seven.

Position No. 1 *Stripping.*—Some shops make two "spots" in the "stripping position." The first for removing wood parts and the second for removing steel parts. Also other shops include in the stripping position a spot for sand blasting steel parts.

Position No. 2. *Repairing trucks.*—Some railroads repair trucks at this position, while same are at car. Other railroads remove the trucks and send them to a truck repair shop, and put the car through the shop on "dolly" trucks, and replace the repaired trucks under the car as it leaves the shop.

Position No. 3. *Repairing frames.*—In this position frames are straightened, and new members applied.

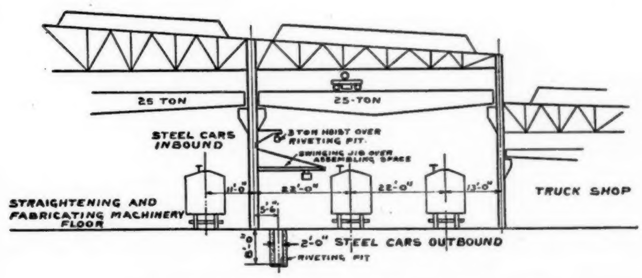
Position No. 4.—Applying steel siding and end sheets, fitting and bolting in place, and reaming holes.

Position No. 5. *Riveting.*—A separate riveting position is maintained by practically all of the railroads replying to the questionnaire.

Note: With composite and wood cars positions Nos. 4 and 5 are often omitted or work done at position No. 3.

Position No. 6.—Applying floors, siding, and all other parts below roof.

Position No. 7.—Applying roofs, running boards, and doors.



Cross-section of the supplemental layout

Position No. 8.—Applying airbrakes and safety appliances.

Position No. 9.—Painting and stenciling. On some railroads certain parts, such as siding and steel sheathing are given one or more coats of paint before being applied, and there is also a practice of having some parts painted on the repair track by second shift men after such parts have been applied by the first shift men.

Type of shop required for progressive repairs

3—Please criticize attached plan shown in A. R. A. shop committee report (p. 1570, *Daily Railway Age*, June 10, 1926), stating if same is applicable to your repairs, and if not, state and show in red pencil the alterations you would make, and support your reasons for such changes.

Only two railroads stated that this plan would not be satisfactory to meet their respective requirements. Nearly all railroads approve of the plan as a whole, with the reservation that some details may have to be changed to meet particular requirements. Following is a summary of principal criticisms, and the committee's reply to them:

Suggestions have been made by several roads that the plan should be modified as to size, to conform with number of cars to be handled. The arrangement in the plan submitted allows for a considerable variation in size without destroying the plan itself. Criticisms have been made by several roads that the transfer table should be eliminated, so as to operate the plant as a double-end shop with no return movement of cars through shop. The committee states that while there is merit in the through movement plan, yet the return movement layout has much to recommend it; for by the return through the shop the parts taken from a car during the stripping are repaired and picked up, and applied on the return trip, thus making a saving in labor of handling such parts. The double-end shop

with through movement requires more ground for trackage, which may not be available. Since both plans have their respective merits, the choice is resolved down to one of space available and type and construction of cars to be repaired.

It has been mentioned by some roads that the fabricating shop is too large. It has been the observation of the committee during the inspection of a number of shops, that many do not have enough room in the fabricating department.

Criticism has been made that the fabricating shop should be outside of the main shop. This criticism has merit, but such an arrangement would mean transporting many parts from the stripping floor to the fabricating shop, for straightening and repairing, and returning them to the erecting floor.

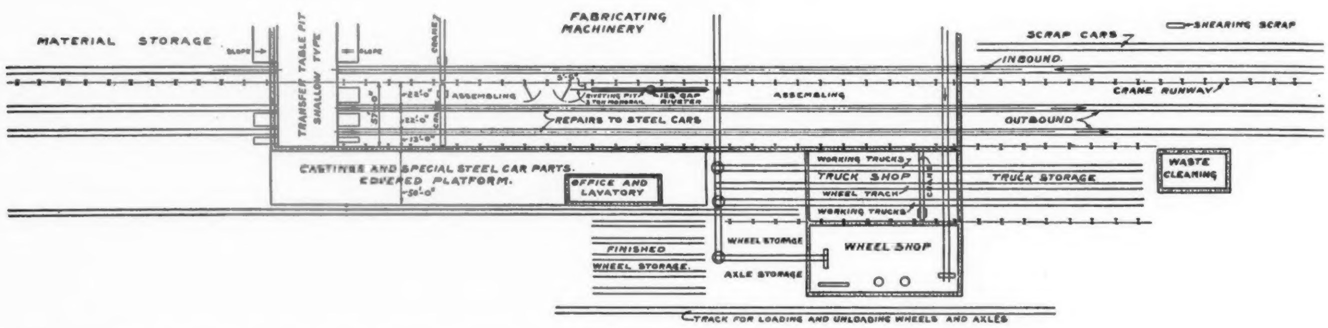
In this connection it has been pointed out that there would be some difficulty in handling large parts from fabricating floor to the erecting floors, such as steel car sides and ends. To facilitate this latter operation the committee suggests locating a riveting pit in one erecting bay. In this arrangement sheets are handled by jib cranes from the fabricating floor to the riveting pit and complete sides and ends transported by the erecting bay crane to the car.

arranged as to trackage, buildings, etc., to operate on a progressive system.

The report is signed by W. A. Callison (chairman), Chicago, Indianapolis & Louisville; J. M. Henry, Pennsylvania; B. P. Phelps, Atchison, Topeka & Santa Fe; J. A. Brossart, Cleveland, Cincinnati, Chicago & St. Louis; J. Burns, Canadian Pacific, and George F. Hess, Wabash.

Discussion

During the discussion the advantages and disadvantages of the double-end and single end shop for progressive car repairs were pointed out. The determining factor in many cases, when deciding as to which type of shop to build, is the question of sufficient ground. Everyone who took part in the discussion was in favor of the progressive system of repairs. J. J. Tatum (Baltimore & Ohio) stated that it has made possible the repairs to some 90,000 freight cars by that road and



Supplemental drawing to car shop layout shown in 1926 report in which provision has been made for a gap riveter and riveting pit in the erecting bay

Several roads state that a separate truck shop is not necessary as they prefer to repair trucks at the position of the car. This does not interfere with the general plan or operation of the shop.

Exception has been taken to repairing wood and steel cars in the same shop. This practice is followed in nearly all shops at the present time as few roads have separate all steel and all wood shops.

Criticism has been made that the finished lumber shed should be on the opposite end of the planing mill, from that shown on the plan submitted. The best position for the finished lumber storage is that nearest the place where the lumber is used. On account of ground restrictions, this position is seldom attained; however, if the ground space permits it would be more desirable to move the finished material shed nearer the shop, or reverse the position of this shed and dry kiln and lumber yard if this gives any advantage in a particular shop layout.

Conclusions and recommendations

From the evidence submitted in the questionnaire, and from observations in shops, made by your committee, the following conclusions are drawn:

1—The progressive system has many advantages over the practice of taking cars into the shop as they come, regardless of series, class or kind of repairs needed.

2—The progressive system will reduce the cost of repairs as all material required for any operation can be handled in bulk to the point where the operation is performed.

3—The quality of the work performed will be improved due to the fact that each man will become a specialist on some particular operation.

4—The supervision required will be reduced and the output of any shop will be increased, other conditions being equal.

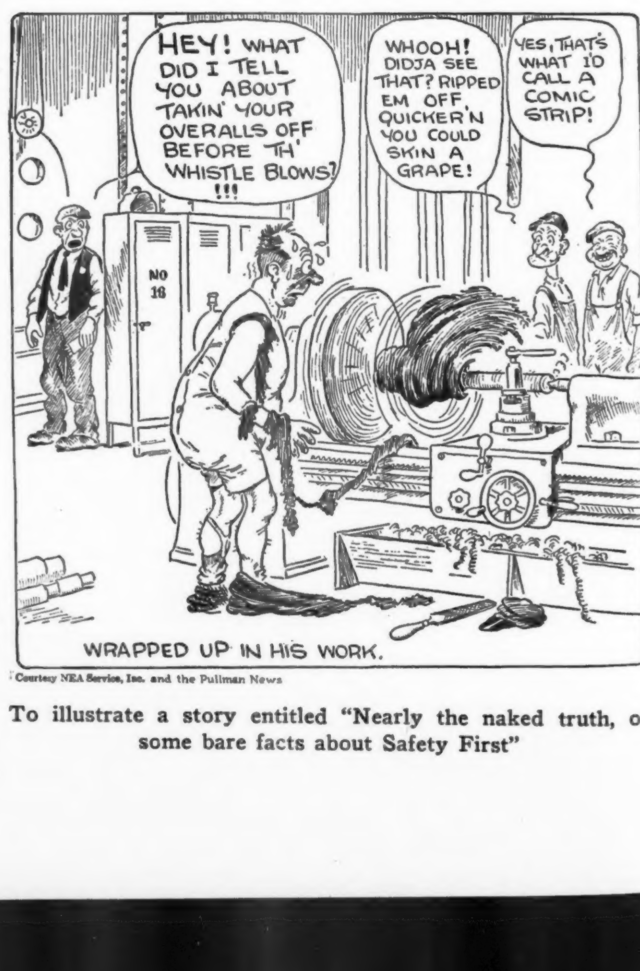
5—To operate the progressive system successfully necessitates shopping at one time a large number of cars of the same series and requiring the same general class of repairs.

The committee recommends that when new car repair plants are to be constructed the submitted layout be given consideration with the view of operating on a progressive system, and the size to be determined by the requirements of the equipment owned by the railroad.

The committee also recommends that when extensions to car repair facilities are needed on any railroad study be given to the existing car repair plants to determine if they can be re-

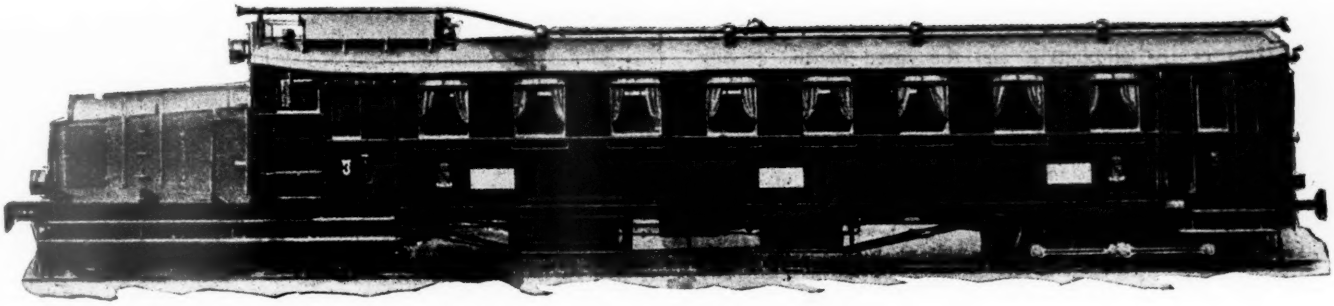
has carried it through periods of peak equipment demands without building any new freight car repair shops, and that, during that period it has been possible to abandon a number of shops not suitably equipped for the repairing of modern equipment.

On motion the report was received.



Courtesy NEA Service, Inc. and the Pullman News

To illustrate a story entitled "Nearly the naked truth, or some bare facts about Safety First"



Saxon Railway 200-hp. motor-rail car equipped with a modified Ward-Leonard transmission system

Internal combustion motive power

Abstracts of the Mechanical Division committee report on automotive rolling stock and a paper on oil-engine locomotives

THE Mechanical Division, American Railway Association, discussed two subjects at its annual meeting in Montreal, Que., June 7 to 10, inclusive, the various aspects and problems of which are closely allied from the standpoint of the mechanical department officer. These subjects were the oil-engine, locomotive, and automotive rolling stock which were presented in a paper by A. I. Lipetz, consulting engineer, American Locomotive Company, and by the report of the Committee on Automotive Rolling Stock, respectively.

Mr. Lipetz in his paper on the status of the oil engine locomotive was especially well received by the convention. He covered practically all of the important developments in both this country and in Europe, showing that we appear to have an established type of Diesel switching locomotive with electric transmission in this country while there has been a tendency in foreign countries to experiment with other types of Diesel locomotives and transmissions. Both countries have made rapid strides in the development of this type of power which is particularly adapted to switching service.

An article reviewing the locomotive and motor car orders placed in 1926 was published in the February, 1927, issue of the *Railway Mechanical Engineer,* in which was included a table which showed that a total of 58 rail motor cars were ordered in 1922 for service in the United States and Canada, and that a total of 162 were ordered in 1926, an increase of a little over 180 per cent. This increase in automotive rolling stock during a period of four years shows the extent to which rail motor cars and trailers are being utilized in steam railroad service, and to what extent developments can be expected in the future. The collecting and assembling of information and data pertaining to the utilization and maintenance of this type of equipment is, therefore, of prime importance to railway mechanical department officers.

Considerable valuable data and information has been collected by the Committee on Automotive Rolling Stock and included in this year's report. The larger part of this material was received from some 20 railroads known to be large users of rail motor car equipment. Following is an abstract of Mr. Lipetz's paper and the committee report on Automotive Rolling Stock, respectively:

The status of the oil-engine locomotive

By Alphonse I. Lipetz

Consulting engineer, American Locomotive Company, Schenectady, N. Y.

A. I. Lipetz

We have at present an established type of Diesel switching locomotives in the United States with electric transmission of 300-600 b.hp. capacity, several switching and suburban locomotives in Germany with hydraulic transmission of 120-400 b.hp. output and four main line locomotives in Russia and Germany of about 1,000 b.hp. with electric, pneumatic and mechanical transmissions. In addition to that we shall soon have in this country several main-line locomotives with electric and mechanical transmissions of 750 to 1,300 b.hp. capacity, and in England a direct-driven main-line locomotive of approximately 1000 b.hp. Experience gained from the performance of these locomotives will, undoubtedly, shape the future development of the Diesel locomotive.

So far our experience has been very limited. Some study has been given to, and a certain development work has been accomplished with, the transmission of power on oil-engine locomotives, probably for the reason that this is the most difficult side of the problem. The next side of it, the Diesel engine itself, only now begins to get its due attention. The three other sides—the cooler, the mechanical parts (or chassis), and the auxiliaries, have not yet been sufficiently studied for the reason that they do not offer great difficulties and that any design of the existing automobile radiators, steam and electric locomotive mechanical parts and auxiliaries, properly modified to suit the new conditions, is at least operative.

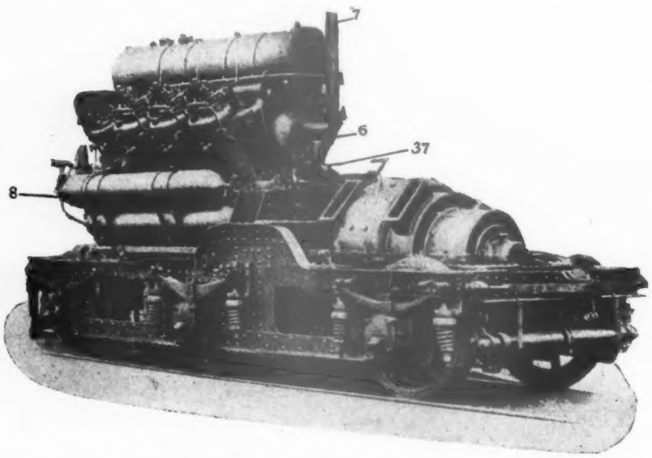
The type of the oil engine depends upon the system of transmission. If the locomotive driving wheels are not rigidly connected to the Diesel engine and their speed is made independent of the rotation of the oil engine by interposing some variable speed transmission, the oil engine may not differ substantially from the conventional Diesel engine. A constant speed oil engine can be used, and the variation of its output can be obtained by varying the mean effective pressure. The transmission will provide for the proper resolution of power into

variable speed and tractive force of the locomotive. If, however, the locomotive driving wheels should be rigidly connected to the crank shaft of the oil engine, and the speed of the driving wheels thus made dependent upon that of the crank shaft, a different oil engine ought to be used. It must permit a variation in torque and speed within wide limits, just as is being done at present in the engine of the steam locomotive.

Consequently, two different types of oil engines must be considered—one for oil-engine locomotives with variable speed transmissions, and another for direct-driven oil-engine locomotives.

Oil-engines for transmission locomotives

The ordinary oil engine must be modified somewhat in order to be made applicable to a locomotive. The first thing to be taken into consideration is the weight of the oil-engine. The weights of the ordinary Diesel engines vary between 120 and 350 lb. per horsepower. As the weight of the present day steam locomotive amounts per horse-power to only 150-160 lb., it can be readily seen that a heavy-weight Diesel engine, which constitutes only a part of the oil-engine locomotive, cannot be applied to locomotives. Only high-speed light-weight Diesel engines can come under consideration and the present practice is to build engines weighing between 35 and 60 lb. per horsepower. Lighter engines have been used so far on rail-cars, and, if developed into large units, may later be used also on locomotives.



Front truck used on the 200-hp. motor rail car operated by the Saxon Railways

In order to obtain a light-weight Diesel engine, it is necessary to raise the speed to the highest limit compatible with reliable service and reasonable maintenance cost. The high speed of the oil engine not only causes a decrease in the weight of the oil engine itself, but it also affects the design of the transmission, or at least some parts of the latter, and results in a lighter weight of the locomotive as a whole. The present practice is to make Diesel engines running from 350 to about 700 r.p.m., depending upon the size and type of the engine used.

The second question which comes up in connection with the oil engine is the type of it—four-cycle or two-cycle, with air-injection or with mechanical-injection, single-acting or double-acting. While the two-cycle engine has many attractive features, it has not yet become possible to develop a reliable high-speed two-cycle engine. A speed of 400 r.p.m. seems to be the limit for a medium size two-cycle engine, and very few two-cycle engines are successfully running even at that speed. As the mean effective pressure is higher in the four-cycle engine by approximately 50 per cent, and as the speed can be raised to above that of the two-cycle engine by about the same amount, the four-cycle engine predominates in the present oil-engine locomotives, as it gives lighter weights per horsepower and occupies no more space than a corresponding two-cycle would. However, there is no reason why two-cycle engines should not be developed for locomotives, especially as the power of locomotives increases.

The double-acting principle does not seem to be applicable to locomotives as long as the Diesel engine occupies a longitudinal vertical position which, so far, has been the most natural thing to do on locomotives with transmission. The space in the cab does not permit the use of a high double-acting engine. Nevertheless, designs of double-acting or opposed-piston engines for locomotives, of 600-1,200 hp. capacity have been made which seem to be worth trying, as the weight of the engine could be reduced considerably in these instances.

With respect to the system of fuel injection, both systems—air-blast and mechanical—have been used. The progress made thus far depends upon the trend of development of this particular feature of the Diesel engine in general. The mechanical injection is now being favored both in this country and abroad, and the use of it on locomotives will, undoubtedly, progress, depending upon the development of reliable high-power and high-speed mechanical-injection engines. So far, engines with 125 b.hp. per cylinder running at a speed of 500 r.p.m. and with 100 b.hp. per cylinder at 700 r.p.m. have been developed for locomotive use, although in marine practice power up to 300 b.hp. per cylinder has been obtained. The highest power per cylinder of a Diesel engine used so far in a locomotive is with air injection, amounting to 175 b.hp. at 400 r.p.m., and requiring piston cooling. It is doubtful whether piston cooling will be found practicable on locomotives, and this fact will probably limit the power per cylinder. High-power locomotives will have to have a larger number of cylinders.

While the compressor of the air-injection engines has been developed to such a perfection that on the present day Diesel engines it has ceased to be a source of trouble as it was in the past, nevertheless the elimination of a compressor will probably appeal to the railroad men, and the future oil engine for locomotives will be that with mechanical injection.

As a whole, the experience so far indicates that the most suitable engine for oil-engine locomotives with transmission of power is the four-cycle, single-acting, solid-injection, high-speed oil engine.

As regards fuel consumption all good oil engines give more or less the same results. The air-injection engine may sometimes produce a better combustion and have a clearer exhaust in a wider range of power and speed, but this advantage is usually offset by the lower mechanical efficiency due to the loss of power in driving the compressor. As a rule all four-cycle high-speed engines of the above mentioned types, either with air-injection or solid-injection, show a fuel consumption per b.hp. hour of 0.4 to 0.44 lb. of fuel oil of 18,000 B.t.u. heat value at full load and normal speed—this corresponding to an overall thermal efficiency of from 32 to 34 per cent. Two-cycle engines give a slightly higher fuel consumption.

Power transmission

Owing to the inflexibility of the Diesel engine, the most natural thing to do is to use some sort of flexible power transmission in which a new intermediate energy is generated (electricity, hydraulic pressure, etc.) and immediately expended, thus permitting a variation of torque and speed at will. Such a system requires, in addition to the full power oil engine, two more full-power machines—a generator, pump, or compressor, as the case may be, and a corresponding electric, hydraulic or pneumatic motor. Assuming that a direct transmission of power by mechanical means is not possible, the full-energy power transmission seems to be the only feasible solution. However, in speaking of the inflexibility of the oil engine, we must not forget that the latter is not absolutely, but only relatively inflexible, and that it can be regulated within certain limits—about 15 per cent above normal and about 75 per cent below normal. Consequently, there would be a certain range within which a direct mechanical transmission of power would seem possible. Therefore there is a certain class of power transmissions, known as "differential transmissions," in which the power is transmitted partly mechanically and partly through an auxiliary medium (electricity, oil, etc.); these transmissions have the advantage of using smaller generators and motors and of giving higher efficiencies within the range where mechanical transmission of power is mostly used.

Attempts have been also made to make use of direct mechanical transmissions. While such attempts have not yet passed the stage of preliminary trials, they merit the most serious consideration as they may lead to very desirable and promising solutions.

The electric transmission is, of course, the most orthodox, the most thoroughly studied, the best worked out in all details and the readiest to use. The idea is not new, as all component parts have been known long ago and have proved separately their reliability during many years of service. Many designs were worked out by various locomotive and Diesel-engine builders during the period of 1908-1913, but none of them was ever materialized.

The most essential part of the electric transmission is the control, or the way of coupling the generator with the motors, and the system of varying and reversing the speeds. There are three distinctive methods of doing that—first, the Ward-Leonard control, which has been used extensively on ships and which consists of a generator and motors, both of the shunt type, separately excited—most often from the same source. The excitation of the motor fields is always in the same direc-

tion; the excitation of the generator, though, is varied in strength by means of a rheostat and, as regards direction, by a reversing switch, so as to suit the speed of the motor and the rotation which is desired. By varying the voltage applied to the armature terminals of a shunt motor having a constant field excitation, the motor speed can be varied in accordance with the variation in the generator excitation, whereas the direction of the motors with constant field excitation depends upon the direction of the current from the generator with variable excitation. Thus by varying the generator fields from full excitation in one direction to full excitation in the opposite direction, the motors rotate from full speed forward to full speed backward.

This system has been, to my knowledge, used on locomotives in only one instance; in the 1000-hp. Baldwin-Knudsen locomotive. In all other cases, both in this country and abroad, a modified Ward-Leonard system has been used, in which the generator is always excited in the same direction, the variation being obtained in strength by resistance, whereas the motors are made of the series type and the rotation of the motors is reversed by reversing the flow of current through their armatures. The direction of the flow of current in the field does not change. This modified system permits the use of series motors which are particularly suitable for traction purposes.

This system has been used extensively abroad and to some extent in this country. It can be found on Diesel railcars built for the Saxon State Railways by Sulzer Brothers of Winterthur, Switzerland, on the Swedish and Swiss railcars and on two 102-ft. articulated cars of the Canadian National, as well as on the 1000-hp Lomonossoff locomotive built in Germany for Russia.

In the two former methods, the control is obtained by inserting resistances in the excitation of the generator. A different type of automatic control developed by Mr. Lemp, formerly of the General Electric Company, is used practically on all Diesel locomotives built in this country, and on seven 60-ft. railcars of the Canadian National. It differs from the modified Ward-Leonard system in that the current from the main generator passes, in addition to the shunt field, through a differential series field, and then through series motors of the locomotive. When the oil engine is running at a certain speed, the field excitation of the generator is modified by the current flowing through the load to suit its own needs. As the load decreases, the flow of current through the differential series field drops and the energizing of the generator field goes up, resulting in higher voltage of the generator corresponding with the higher speed of the motor. Thus the speed of the motors automatically stabilizes in accordance with the load, drawing substantially constant energy within certain limits. The power of the generator is, in this way, automatically resolved into torque and speed to suit the condition of the load. The reversal is obtained in the same way as in the modified Ward-Leonard system by reversing the polarity of the motor-armature or of the field.

The efficiency of the electric transmission varies between 65 and 85 per cent, depending upon the load and the speed. Even higher figures have occasionally been obtained during special tests with a 1000-hp. Russian oil-electric locomotive on a testing plant. The efficiencies of the transmission used in this country are not known exactly, but for calculation purposes it is being taken from characteristic curves of the generator and motors as approximately 75 per cent.

Next comes the hydraulic transmissions, of which the most used is the Lentz transmission or gear, as it is sometimes called, for the reason that it does not change the speed of the driving wheels gradually, but stepwise.

Several other hydraulic transmissions have been brought forth, such as Huwiler, Lauf-Thoma, Hele-Shaw, Naeder, William-Janney and many others, some of which have not yet passed the experimental stage. The latter transmission is also known in this country as the Waterbury gear, developed by the Universal Engineering Corporation in Montreal.

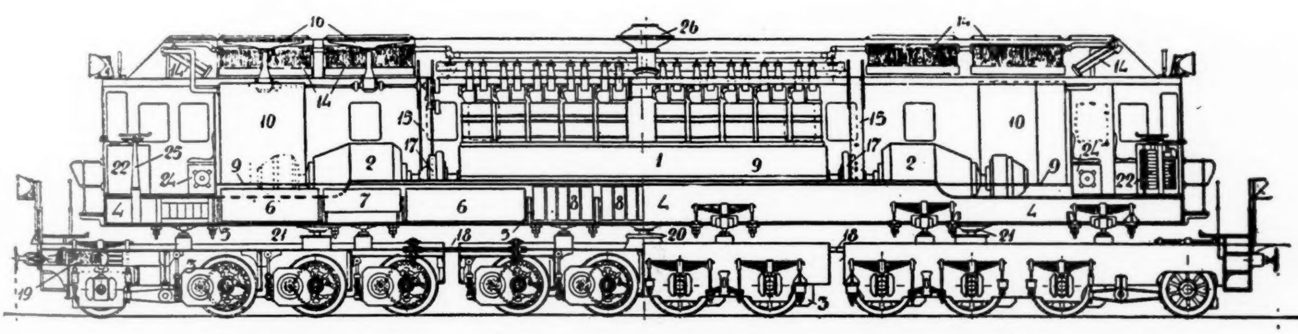
Quite recently a new hydraulic transmission, system Rosén, was installed in a 300 b.hp. 2-4-2 locomotive built for the Kalmar Railroad in Sweden. The transmission consists of a separate motor and pump connected by means of piston valves which control the amount of working fluid and consequently the speed. The inventor claims an efficiency of about 75 to 85 per cent and the possibility of using the transmission for powers up to 2000 hp.

The difficulty with the hydraulic transmissions seems to lie in the low efficiency resulting from the heating of the oil which, once started, has the tendency to increase in temperature very rapidly. It seems that the presence of air in the oil affects very materially the rise in the temperature, and that some transmissions are more likely to absorb air when running than others. Lentz, for instance, claims that he has entirely overcome this difficulty. This may be due to the low pressures which Lentz employs—about 50 to 150 lb. per sq. in. at full speed and 400 to 500 lb. per sq. in. at starting, while others are applying pressures from 400 to 600, and 1,200 to 1,500 lb. per sq. in., respectively.

The idea of pneumatic transmission is probably one of the first types which occurred to those interested in Diesel-locomotive designs. As far back as 1909, V. A. Stuckenberg, general manager, Tashkent Railroad, Russia, suggested rebuilding steam locomotives in the following way: to replace the tender by a unit carrying a Diesel engine and a compressor, use the boiler as a compressed-air storage tank, and to let the air work in the existing locomotive cylinders in the same way as steam. The project was not considered at that time practicable, and the idea was abandoned. About the same time, James Dunlop, Glasgow, Scotland, came out with a similar proposition.

However, air transmission as suggested by Stuckenberg and Dunlop could hardly offer promising results on account of the low efficiency of air motors and of the cooling effect of air during expansion, which latter would result in lubrication and other difficulties. Schelest, in his book on Diesel locomotives, calculated that the overall efficiency of a Diesel locomotive with air transmission would range between 13.4 and 15.3 per cent. While this is almost twice the efficiency of a steam locomotive, the high first cost of such a locomotive, probably from 3 to 3.5 times that of the steam locomotive, would render the proposition impracticable, and explains why the building of a Diesel locomotive with ordinary air transmission was never seriously attempted.

Nevertheless, the Maschinenfabrik Esslingen, jointly with the



Working drawings of the Russian 1,030-hp. Hackel diesel-electric locomotive showing the twin generators and the arrangement of the ten driving motors on three trucks

M. A. N. Company of Germany, developed a 1,000-hp. Diesel locomotive with air transmission. The design consists of a six-cylinder submarine type M. A. N. engine, referred to above, which drives a compressor. Air compressed to about 110-125 lb. per sq. in., and thus already heated to about 500 deg. F., is further heated by the exhaust gases to approximately 700 degrees F. The engine is now completed and undergoing tests in Germany, so we may soon have data on its performance.

The so-called differential transmissions referred to are very ingenious and numerous but, so far, none of them have been applied to more than railcars and trucks. Only one 500-hp. hydraulic transmission of this class—the Schneider gear—was built, but has not yet been applied to the locomotive for which it was intended.

Gear-clutch transmissions have been in use for a long time in small industrial locomotives and railcars, mostly in France and in Germany, for powers ranging from 30 to 200 hp. They represent a combination of clutches, of a set of gears of the sliding type, of universal joints and bevel gears. Sometimes chains, jack shafts and rods have also been used. The most notable difference in the latest designs of gear-clutch transmissions for cars and locomotives is the replacement of the shifting gear by a series of gears with a corresponding number of clutches, all gears being always in mesh. The friction clutches engage one gear at a time, all other gears remaining disengaged. The change from one speed to another is effected by slipping between parts of the engaged clutch. The clutches are operated manually, pneumatically, hydraulically or magnetically.

The most daring application of a gear transmission has been recently made in 1,000-hp. Diesel locomotive which has been built in the Hohenzollern Locomotive Works at Düsseldorf, Germany. The locomotive has been ordered for main-line service on the Russian Railways in competition with the 1000 hp. oil-engine locomotive with electric transmission. The locomotive is of the 4-10-2 type, has a reversible 1000 b.hp. Diesel engine which acts on a jack shaft by means of three gears always in mesh, with three friction clutches operated magnetically.

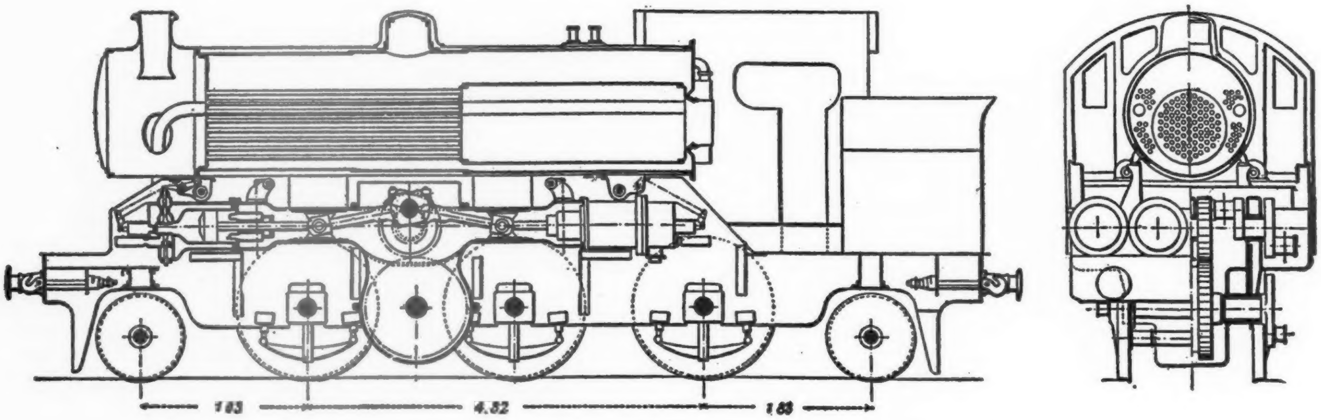
Description of oil-engine locomotives

We shall now describe several completed oil-engine locomotives and railcars with Diesel engines. A Swedish Diesel-electric car equipped with a 300 b.hp. oil engine, actually serves as a locomotive. It has also a baggage and mail compartment. The electric generator is coupled directly to the oil engine and is of the eight-pole shunt-wound type, provided with a separate series winding which is used for starting the oil engine by driving the generator as a motor from a storage battery for about from one to one and a half seconds. The speed control is obtained by varying the excitation through a controller on either end of the locomotive.

The fuel consumption is between 2.0 and 3.5 lb. of oil per 100 gross ton-miles. According to reliable information from two Swedish railroad companies, this represents an economy in money of 50 to 60 per cent as compared with coal-steam operation. The cost of maintenance of the machinery is very low. For the oldest motor car, which has been in service since August, 1913, the total maintenance cost amounts to 2.16 cents per car mile. At present there are in Sweden in operation altogether 14 cars of this type on some eight small railroads. A complete report of their performance was published by M. R. Jourdin, general manager of the French South-Eastern Railway, after a visit to Sweden in September, 1922. His figures are in conformity with those given above, as are also the results obtained from one of the latest locomotives, delivered in 1924 to the Railway Company of Tunis.

Soon after the appearance of the Swedish motor cars, several Diesel-electric motor cars were built for the Saxon and Prussian Railways by Sulzer Brothers in Winterthur, Switzerland, jointly with Brown, Boveri & Company in Mannheim, Germany. Tests made with the car on the Saxon Railways showed a fuel-oil consumption of 2.92 lb. per car-mile, or 3.86 lb. per 100 ton-miles.

One of these cars was rebuilt into a Swiss railcar with a solid-injection oil engine and electric transmission of the modified Ward-Leonard type. The Sulzer Brothers tests have shown a fuel consumption of 0.446 lb. of oil per b.hp. hour. They estimate the total efficiency of the electric transmission (generator and motors), together with the mechanical transmission (rods, pins and axles) at 72 per cent, corresponding to a total consumption of oil of 0.62 lb. per rail hp.-hr. They further claim that the consumption of oil per 100 ton-miles is equal to 1.9-3.2 lb. (these figures are very close to those given above by the Swedish railroads), and that this corresponds to only one-fourth of that on regular steam locomotives in Swiss suburban traffic.



Elevation and cross section of the 1,000-hp. Kitson-Still locomotive (Dimensions in meters)

The 2-10-2 1,000-hp. Diesel-electric locomotive built in Germany for Russia, known as the Lomonossoff locomotive, is equipped with the 1,000-b.hp. M. A. N. engine. It was first tested on a stationary locomotive testing plant in Germany, and later sent to Russia for regular service. At the testing plant it ran under variable load at variable speeds, each variable being constant, however, during a certain continuous run. The average loads during a series of three trials lasting from 55 to 94 min. were 467, 845 and 876 hp.; the corresponding tractive force was 9,540, 20,400 and 33,600 lb. The consumption of fuel oil per one rail hp.-hr. amounted to 0.537, 0.525 and 0.558 lb., the later figure including the oil for driving the cooling fans. The over-all thermal efficiencies, including all auxiliaries and losses, obtained from numerous tests in addition to the three above mentioned, ranged between 18 and 24 per cent. The efficiency of the electric transmission itself fluctuated normally between 73 and 85 per cent, although occasionally efficiencies of 93 per cent were recorded.

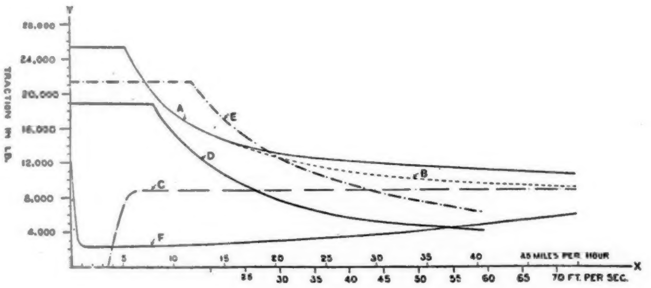
Elaborate comparative tests were made on the same testing plant with an 0-10-0 superheated steam locomotive. At three different tests with loads, speeds and tractive forces, approximately the same as those during the three trials with the Diesel-electric locomotive, the fuel consumption figures were 1.87, 1.64 and 1.86 lb. per rail hp.-hr. of the fuel oil used in the Diesel engine, or over three times as much as those of the Diesel-electric locomotive.

The locomotive has now been in main-line freight service for over two years and has proved to be very reliable. However, some troubles resulting from overheating of electric motors on long grades were experienced. The motors are likely to get hot at high tractive forces and speeds below 20 m.p.h., whereas the air cooling of the motors is more effective at speeds over 20 m.p.h. The locomotive cannot be used continuously at full power at speeds less than 10 m.p.h. In some instances, on very long grades, the speed had to be raised and the tonnage corespondingly reduced. Some difficulties were experienced with electric motor dust strainers, which had been very easily clogged up with sand and oil, thus interfering with proper air ventilation of the motors. On several occasions it

resulted in considerable damage caused by loosening of the retaining rings of the motors.

It was found during special trips made from Moscow to the Caucasus, both with the oil-electric and steam locomotives of the same power, that the oil-electric locomotive consumed per each ton-mile 22.2 to 25.0 per cent of the amount of oil burned on a coresponding steam locomotive, thus showing a saving of 77.8 to 75 per cent. The first figures refer to cold weather, when the oil-electric locomotive requires less fuel for the water cooler and can haul heavier trains on account of better cooling of electric motors, and the latter figures to warm weather, when the steam locomotive radiates less heat.

On the basis of obtained information the operation cost per ton-mile in Russia, including depreciation, is estimated to be 18.0 to 25.8 per cent in favor of the oil-electric locomotive. This checks up very well with the actual operation-expense sheet for the first few months after the locomotive was placed in service, and with the above mentioned figures for the American oil-electric locomotives, if the locomotives are fully utilized.



Estimated indicated tractive force curves of the Kitson-Still locomotive

A 2-6-8-6-2 type oil-electric locomotive has been built at the Putiloff Works, Petrograd, Russia, which is known as the Hackel locomotive. The oil engine is a ten-cylinder, solid-injection Vickers engine, developing 1030 b.h.p. at 395 r.p.m. It drives two generators rated at a maximum of 380 volts and 1,500 amperes. The two generators can be connected in parallel for a combined delivery of 3,000 amperes maximum. The locomotive has ten driving axles with motors geared to each axle.

The axles are distributed between three trucks supporting the frame and the superstructure. The trucks are interarticulated by rigid drawbars through which the pull is transmitted without affecting the body of the locomotive. Two vertical fans deliver the cooling air to the radiators. The locomotive has recently been placed in service but very little is known about it. Special tests made with the locomotive showed small fuel consumption —about 24 per cent of that of the ordinary steam locomotive.

Locomotives with direct drive

The great success of the steam locomotive must, to a very large extent, be attributed to George Stephenson's fortunate idea of a direct connection between the steam pistons and wheels. It is, therefore, quite natural that present-day Diesel-locomotive designers are striving to preserve the simplicity of the direct-driven steam locomotive for the oil-engine locomotive. In order to do that they have had to solve the problem of starting and, to a certain extent, that of speed variation. This has not yet been satisfactorily done, but very interesting attempts in this direction have already been made.

The Borsig-Sulzer locomotive was the first attempt of this kind. It had a direct connection between the Diesel-engine crank shaft and the driving wheels by means of side rods. Dr. Diesel himself was the designer of the locomotive, but he did not seem to be fully cognizant of the inflexibility of the Diesel engine and its poor adaptability to locomotives. He tried to solve the problem by using compressed air for starting the locomotive with the train. The engine had to be run with compressed air until the speed of the locomotive and train reached the ignition speed, which for this particular locomotive was 6.6 m.p.h. In order to supply enough starting and accelerating power a separate compressed air outfit had to be provided. The locomotive was, therefore, equipped with two Diesel engines—a main engine and an auxiliary engine. The main engine was a four-cylinder V-type single-acting two-cycle engine of 1000 m.p.h. at 304 r.p.m. The auxiliary engine was a vertical two-cylinder two-cycle engine of 250 h.p., cylinders 12 in. by 15 in., connected with a horizontal multi-stage compressor; the object of this engine was to generate air for starting, supercharging and other purposes.

Starting by air, however, did not give satisfactory results. In order to obtain good efficiencies it was necessary to apply high rates of expansion, which resulted in low temperatures at the end of expansion and cooled the cylinders to such an extent that ignition became impossible. Short expansions, on the other hand, resulted in very low efficiencies and consequently in high consumptions of air which the auxiliary engine was unable to supply. In addition to this, the crank shaft broke at the end of 1913 and was replaced in spring, 1914, and some other parts also proved to be defective. The locomotive was all the time undergoing repairs and changes; nevertheless, several satisfactory runs were made and valuable experimental data were collected but the work was abruptly stopped at the beginning of the world war. During the war the locomotive was scrapped.

Two designs of direct-driven locomotives of considerable size, embodying the Still principles of starting, have recently been worked out in detail, and at least one locomotive is at present under construction in Leeds, England, at the plant of Messrs. Kitson & Company. Another was to be built in France at the works of Schneider & Company in Creusot, but for some reason the work has been temporarily postponed. The Still engine is a combination of an oil engine with a steam engine, the steam being generated in a separate boiler by the waste heat of the oil engine, and being expanded in the oil-engine cylinder, on the other side of the piston. The boiler is placed in communication with the water jackets of the engine cylinders, and thus both the cylinder jacket heat and the exhaust gas heat are utilized for steam generation in the Still engine.

The Still engine, in addition to its low fuel consumption, offers a very good combination for train starting, steam being an ideal fluid for this purpose. Of course, if the engine has not been run before starting, it becomes necessary to heat the boiler with a specially provided oil burner in order to generate steam for starting. However, in so doing the cylinders are warmed up, ignition is facilitated and starting on oil is rendered much easier. The presence of a boiler on an oil-engine locomotive may prove to be of great value, as it offers a large amount of stored and available energy, especially with the oil burner in operation, which can be utilized on heavy grades and in emergencies, even though at the sacrifice of fuel economy. There are, of course, disadvantages to the system.

The Kitson-Still locomotive is shown in one of the illustrations. The oil engine is of the four-cycle type, and has eight horizontal cylinders driving a four-crank shaft placed underneath the boiler and geared to a jack shaft. The boiler is of the locomotive type with a modified fire box. The outside cylinder ends are those of the oil engine; the inside ends are those of the steam engine. The cylinders are 13½ in. in diameter by 15 in. stroke. At 450 r.p.m., which corresponds to a locomotive speed of 45 m.p.h., the crank shaft horse-power is about 880 on internal combustion sides, and about 1000 on both combustion and steam sides. Rail tractive force at this speed is 7,000 lb.

Starting takes place through the action of steam on the inside surfaces of all eight pistons. The starting tractive effort is 25,450 lb. at boiler pressure of 200 lb. per sq. in. The estimated weight of the locomotive is 156,800 lb., that is, 157 lb. per horse-power at maximum speed, or almost the same as in ordinary steam locomotives. The wheel arrangement is 2-6-2; the weight on drivers is 114,240 lb.; the adhesion factor is thus 4.5. The locomotive is almost completed and test results should be known this year.

The Still locomotive represents a radical departure from previous oil-engine locomotives. A locomotive with a constant power prime mover and a transmission of the kind described above has a hyperbolic speed-tractive force characteristic, which drops very rapidly with the increase in speed. The locomotives with direct drive as the Borsig-Sulzer, if at all possible, give a straight line (constant torque) characteristic with slight increase at low speeds. The steam locomotive speed-tractive force curve lies somewhere between the hyperbola and straight line, and the Still locomotive's curve comes closer to the steam line than that of any other oil-engine locomotive. The estimated indicated tractive-force curves of the Kitson-Still locomotives in comparison with various steam locomotives are shown in one of the charts. Curve A corresponds to the Kitson-Still locomotive with boiler at full service (burners turned on); curve B to same with burners gradually cut out; curve D to a steam locomotive with 18-in. by 24-in. cylinders and 58 in. drivers; curve E to a steam locomotive with 20-in. by 26-in. cylinders and 68-in. drivers. Curve C gives the tractive force of the Kitson-Still locomotive obtained from internal combustion ends only.

Curves A and B, it can be seen, have the characteristic appearance of steam locomotive tractive-effort curves. This is, of course, a great advantage of the Still system, resulting, as many other advantages, from the fact that the Still locomotive is a combination of an oil engine with a steam engine. This combination, however, especially in a locomotive, also has its disadvantages; for instance, the realization of tractive-forces

beyond certain limits will require the application of the oil burner and will cause a loss in thermal efficiency. The boiler will then be subject to wear, accumulation of scale, stand-by losses, maintenance repairs, although to a lesser degree than in ordinary steam locomotives, but, nevertheless, to an extent depending upon the length of time during which curve A is used instead of B. If steam is very often used at low speeds on heavy grades it may impose on the boiler a great amount of work and result in an appreciable increase in fuel consumption and cost of maintenance. The necessity of using oil for the burner, in order to be able to control the fire easily, may not be favored in places where coal is cheap. On the other hand, on level roads, with uniform conditions of traffic, the Still locomotive, especially with passenger through trains, may run for long periods of time on oil with very little steam, and that probably steam which is being generated by waste heat from the oil-engine exhaust. A great advantage of the Still locomotive is the elimination of cooling arrangements.

Discussion

In discussing Mr. Lipetz's paper, Dr. W. F. M. Goss remarked that the inroad the oil-engine locomotive is making into the field of the steam locomotive is not to be regretted, as this is progress. He called attention to the fact that we ought to be on our mettle to see that the steam locomotive is not entirely left out of the running.

A. H. Fetters (Union Pacific) stated that the development of the Diesel locomotive has raised two fundamental problems: The development of a suitable prime mover and the development of ways and means for converting that energy at constant speed into the necessary varying torque required by the variable speed of the vehicle. A great deal remains to be done in the development of a suitable prime mover for the reason that with the present size of engines, clearance limitations will not permit building oil-engine locomotives in the sizes required in this country. He also stated that ultimately, electric transmission will win out on account of its great flexibility, its fair ratio of conversion of power and the fact that it is generally understood.

In commenting on the problems arising in the development of a new line of power, Professor A. J. Wood (Penn. State College) said that the subject of internal combustion engines is new compared with the subject of steam engines and that we must not forget the fact that the engine itself, independent of its special application to rolling stock, is in the state of flux. The limitations at the present time in internal combustion engine design, he said, are largely metallurgical, but the developments which are now going on promise greater per cent increase in efficiency of the oil engine as applied to transportation than is possible with steam.

Report on automotive rolling stock

C. E. Brooks
Chairman

In order to secure information on the present use of automotive rail cars on Class I railroads, a general inquiry has been made regarding the size, power and age of all such equipment. In addition, statements have been secured from some twenty railroads known to be large users of rail cars, giving detailed information as to costs of operation for the calendar year 1926, reliability of service and general operating experience.

Summary of data from Class I railroads

Number of cars—The number of cars listed in the replies totals 332, of which 189 are mechanical drive, and 133 electric drive. This type of equipment was originated in 1905, and had a steady growth until 1915, after which there was a period of inactivity until 1921, when renewed interest was shown, and from that time onward there was a rapid increase in the number of cars, the number being trebled from 1921 to 1926.

Transmission—The number of mechanical drive cars was approximately double that of the electric drive cars until 1925, during which year the number of mechanical drive cars did not increase at the prevailing rate, and it appears probable that by the end of 1927 the number of electric drive cars will equal or exceed that of the mechanical drive cars. Some of the reasons for this are to be found in the greater reliability and serviceability of the electric models, simplicity of control and of double-end operation.

There are also a few storage battery cars which were included under the electric drive cars. There is a general tendency at the present time to convert the storage battery cars to gasoline electric drive. There is one experimental hydraulic transmission in use on the New Haven, but the cost figures on this gear are not indicative of normal operating conditions, because of accident repairs not chargeable to the hydraulic feature. The fuel costs on this car are comparable to those obtained with electric drives, but there is an additional cost for transmission oil which has been high due to occasional leakages.

Horsepower—The average horsepower of the cars over the period 1906-26 is shown in Fig. 1.

The power of electric drive cars, as shown, was between 175-200-hp. until the year 1925 when a number of 250-hp. engines were introduced and several railroads put into operation double power plant cars running between 400-500 hp., raising the general

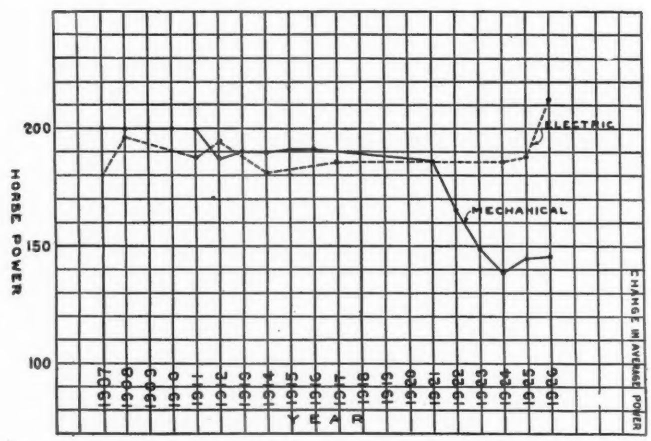


Fig. 1—Average horsepower of rail motor cars over a period from 1906 to 1926

average to 273-hp. for this last year. The average horsepower of mechanical cars started out at 200-hp. with the McKeen units, and has varied somewhat erratically due to the fact that in 1912 a group of 60-hp. cars was built, in 1917 a 300-hp. car was put out, and again in 1921-22 small engines were temporarily in vogue. At the present time there seems to be a tendency to limit the mechanical transmission to cars in the neighborhood of 150-hp. or less. Cars of 180-275-hp. are used with single trailers, and cars over 400-hp. are used with from two or three trailers.

Weight-Length—The weight of rail cars is plotted against horsepower in Fig. 2 for mechanical cars, and in Fig. 3 for electric drive cars. In Fig. 4, weight is plotted against length. Fig. 2 indicates that the average light weight per horsepower for a single mechanical car is about 350 lb. and that when these cars are operated with trailers the weight per horsepower rises to approximately 630 lb. Electric drive cars average approximately 400 lb. per horsepower operated without trailer, or 700 lb. per horsepower with trailers. The weight per foot of car length is

Table I—General average of rail car operating costs as reported by several Class I railroads cents per mile

Type of equipment	Mechanical Single	Mechanical Trailer	Electric Single	Electric Trailer
Crew	18.69	22.93	18.85	20.79
Fuel	4.59	6.05	10.45	12.10
Lubricating oil	.86	.90	.88	1.00
Supplies, Cleaning, Enginehouse	2.83	3.12	1.66	2.10
Repairs	11.40	10.85	6.31	5.45
Total	38.37	43.85	38.15	41.44
Average daily mileage	101	122	165	203

approximately 750 lb. for small mechanical cars, and 1,100 lb. for large mechanical cars. Electric drive cars average 1,400 lb. per foot of car length, due in part to the increased weight of the transmission and in part to the fact that these cars have in general heavier duty engines and are of more substantial construction throughout.

Power plant—Nearly all rail cars use six-cylinder engines, the four-cylinder engine being now confined to the smallest type of car, having only 60-70 hp., the one notable exception to this being the four-cylinder and eight-cylinder Diesel engines on the Canadian National, which are rated at 200 hp. and 400 hp. respectively.

The limiting cylinder size of modern cars is 7½ in. by 9 in. for gasoline engines, although some of the older gasoline and distillate engines had 8 in. by 10 in. and 10 in. by 12 in. cylinders.

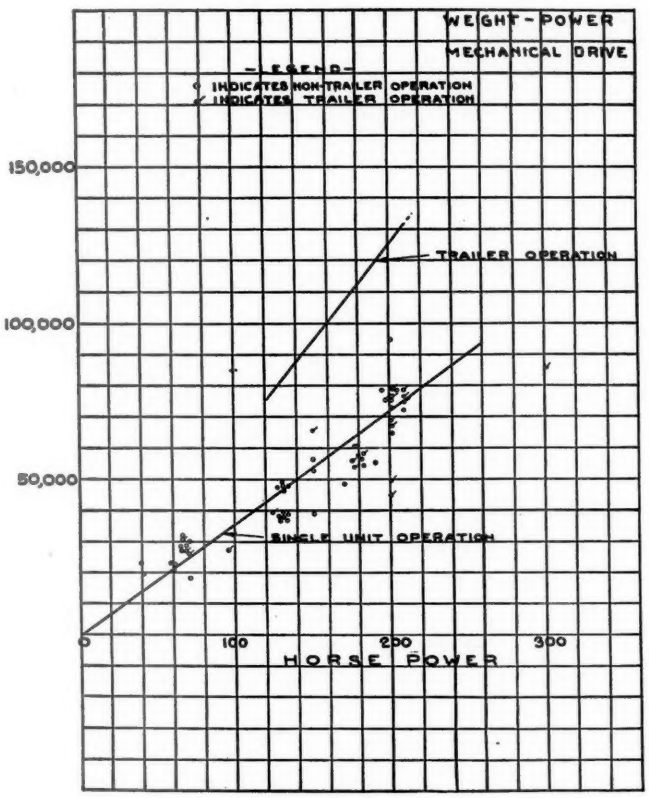


Fig. 2.—Weight of mechanical drive motor rail cars against horsepower

Diesel cylinders now in use measure 8¼ in. by 12 in. It is not thought likely that the gasoline cylinder will come back to these very large sizes, but there is no reason to believe that the Diesel engine cannot be used with cylinders as large as may be desired.

Engine speed of the gasoline engines of 20 years ago was limited to 350 r.p.m., which was increased until in 1925 there were a number of cars operating at 1,600 r.p.m. and 1,700 r.p.m., but the best practice at the present time seems to center around heavy-duty gasoline engines running at speeds from 1,050 to 1,200 r.p.m. The first Diesels put into operation ran at 750 r.p.m. and it seems that this is increasing to a rated speed of 900 r.p.m.

Cooling system—The preponderance of cooling systems are built around cellular radiators mounted either on the front or the side of the car. In some cases the front-mounted radiators are assisted by small over-head radiators which are normally dry, but come into action when the engine speed is increased beyond the idling speed.

A few cars have been built, notably nine on the Canadian National, and two on the N. Y., N. H. & H., in which the radiation is of the finned-tube type mounted on the roof of the car and dependent for air circulation solely on the motion of the car. This has two chief advantages; the first being that the radiation system may be only partially filled when the car is standing, so that the water is confined entirely inside of the car body, thus minimizing the danger of freezing in cold weather; secondly, the flow of water may be by-passed at engine-idling speeds so that excessive cooling will not be experienced when coasting down long grades with the throttle closed. It also makes for rapid warming up of a cold engine.

Air circulation through the cellular type radiators is obtained by mechanically-driven fans on mechanical cars, and with electric fans on cars having electric transmissions.

Fig. 5 shows number of gallons of water circulated per minute plotted against engine horsepower. Fig. 6 shows the square feet of radiation plotted against horsepower. It will be noted that there is considerable divergence of the points plotted for individual cars, which may be partly explained by the difficulty of measuring these quantities, and by the fact that numerous other variables are involved, a relatively large amount of radiating surface and high water flow being required in those cases where it is thought desirable to operate engines at low-jacket temperatures. This is also true in cases where the engine exhaust manifold is water-cooled. It is stated that a water-cooled exhaust manifold increases the heat flow to the radiators approximately 20 per cent on gasoline engines and 4 per cent on Diesel engines.

Passenger accommodations—Seat spacing varies from 26 in. to 35 in. center to center, and averages 31 in. Aisle varies from 18½ to 30½ in., with 21 in. the predominating figure. Width of seat per passenger varies from 15¼ in. to 20 in., the almost universal practice being to use 3-2 spacing. There is usually one saloon with dry hopper per car.

Hot water heaters are almost universally used in preference to hot-air type though cars vary so greatly in insulation, use of double windows, location, etc., that the amount of radiating surface varies considerably. Aluminum and finned steel or copper tubes are used to reduce the weight and the system in some cases.

Vacuum fuel feed systems predominate, but a number of cars use air pressure on the main tank, while others use a mechanical pump feeding a gravity tank, with an overflow return to the main tank, and some automatic electric pumps are being tried out.

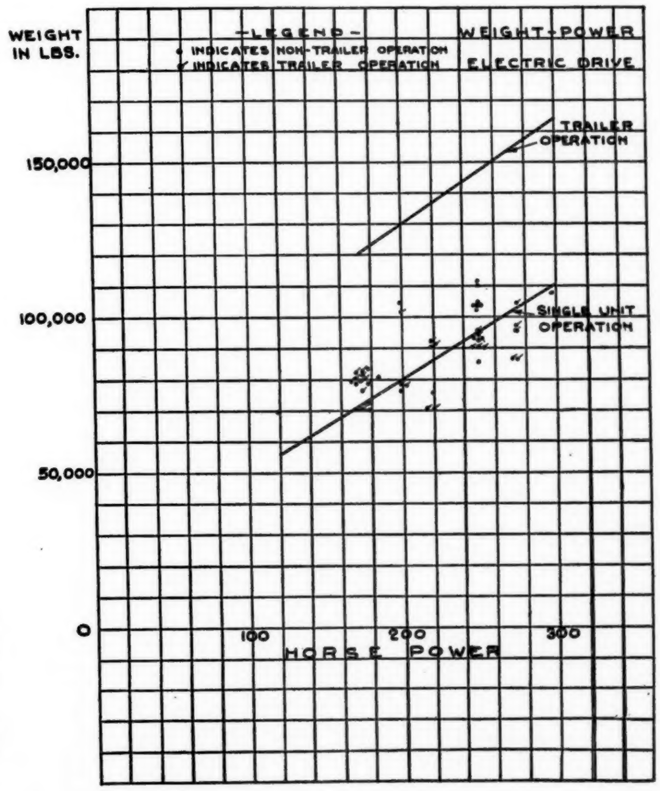


Fig. 3.—Weight of electric drive motor rail cars against horsepower

There is room for further development in means for insuring reliability of fuel feed and the removal of foreign matter.

Life of equipment—There is some divergence of ideas regarding the possible life of rail car equipment, and also in regard to the allowances made for this in accounting. It seems to be generally agreed that the car is good for some 20 to 30 years, the power plant 10 to 15 years, mechanical transmissions estimated at from 5 to 10 years, and electric transmissions from 10 to 25 years. Few of the railroads in question, however, have been using equipment a sufficient period of time to speak with authority on this point. The following statement from one of the pioneer railroads on the use of rail cars is, however, highly significant:

This railroad has cars which have been in daily operation for 20 years, and are now in practically as good condition as when put into service. Of

29 cars now operating, two have been in service nearly 21 years, five nearly 20 years, and all but 10 have been in service over 15 years.

The mileage performance over the total number of years would be difficult to ascertain, but it is a fact that most of our cars have passed the million-mile total, with some of them well along in the second million cycle.

Seven of the original 10 motor cars have been removed from service. These, however, were built during the early experimental days of the rail cars, and were of a different construction from those produced a short time later. The matter of obsolescence has not effected our cars as minor changes have been made from time to time, bringing them up to date, although these changes have not disturbed the original construction more than superficially.

Class of service—The majority of the rail car operations are in branch line service, although several of the western railroads use single cars on main line local work. The double power plant cars operating with two and three trailers on the Seaboard and Lehigh Valley lines also handle main line local traffic.

Table II—Performance data

Road	Per cent serviceable days		Miles per total failure	
	Mechanical	Electrical	Mechanical	Electrical
Baltimore & Ohio	....	....	.....	.....
Boston & Maine	74	....	.....	.....
Canadian National	95.3	*81.7	.....	*9,112
Central Vermont	....	96	†15,000	.....
Chicago, Burlington & Quincy	87	....	.....	.....
Chicago Great Western	86	94	9,576	17,207
Chicago, Milwaukee & St. Paul	....	....	.....	.....
Chicago & North Western	66	....	.....	.....
Erie	79.1	95.4	.....	.....
Great Northern	....	....	.....	.....
Lehigh Valley	87.7	97.6	15,951	No failures
New York, New Haven & Hartford	73.3	93.1	11,570	38,900
New York Central	83.4	....	6,555	.....
New York, Ontario & Western	....	....	.....	.....
Northern Pacific	....	....	.....	.....
Pennsylvania	85.7	91.4	24,070	48,235
Reading	94.5	83.6	2,873	8,722
Seaboard Air Line	....	....	.....	.....
Southern Pacific	70.5	....	37,428	.....
Union Pacific	89.1	....	22,724	.....

*Diesel Electric. †Storage battery.

The daily average mileage of all schedules submitted is 148 miles per day per car. The longest daily mileage shown on several railroads runs between 300 and 400 miles, although on the eastern railroads figures in excess of 200 miles per day are rare.

With very few exceptions, the rail cars are used to replace,

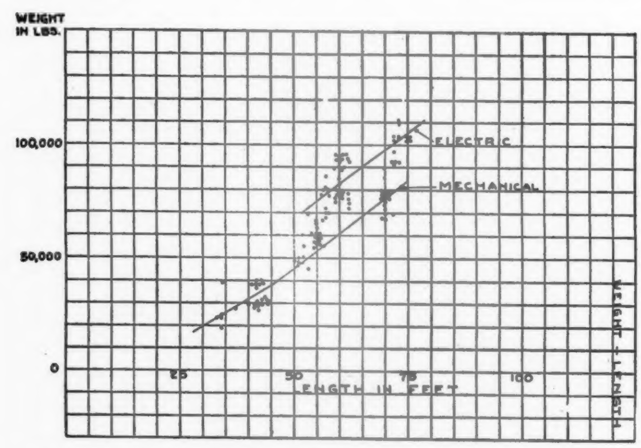


Fig. 4.—Weight of motor rail cars against the length

rather than to supplement or extend steam service. In many cases rail cars permit continuing runs which otherwise would have to be abandoned.

Crew assignment—Three railroads report a normal crew of three on a single car. Other railroads report two men, this as the usual crew on a single car with an occasional third man when the baggage is heavy. When one trailer is hauled, several railroads operate occasionally with a two-man crew, but the normal crew on a single car and trailer is three men. Three railroads report four-man crews on this combination of equipment when the baggage is heavy or when operating in main line service.

Costs—Typical operating costs of rail car equipment are set forth in Table I. It has been necessary in some cases to condense and group items in order to permit ready comparison. Obviously the age of the cars and the average daily mileage must be given due consideration in making comparisons.

Fuel—A large majority of rail cars are using commercial gasoline fuels which run slightly better than government specifications, the cost varying between 13 cents and 21 cents per gallon, with an average of 18 cents.

Considerable interest has been shown toward the possibility of utilizing the cheaper low-grade fuels such as distillate and Diesel oil.

The Southern Pacific is using a mixture of one part gasoline to two parts of distillate. The Union Pacific has satisfactorily used straight distillate for a number of years, mostly in large-sized, low-speed engines, this being accomplished through the use of individual carburetors of special design for each engine cylinder. Several other railroads have experimented along these lines with various degrees of success.

The Canadian National has done pioneer work in applying

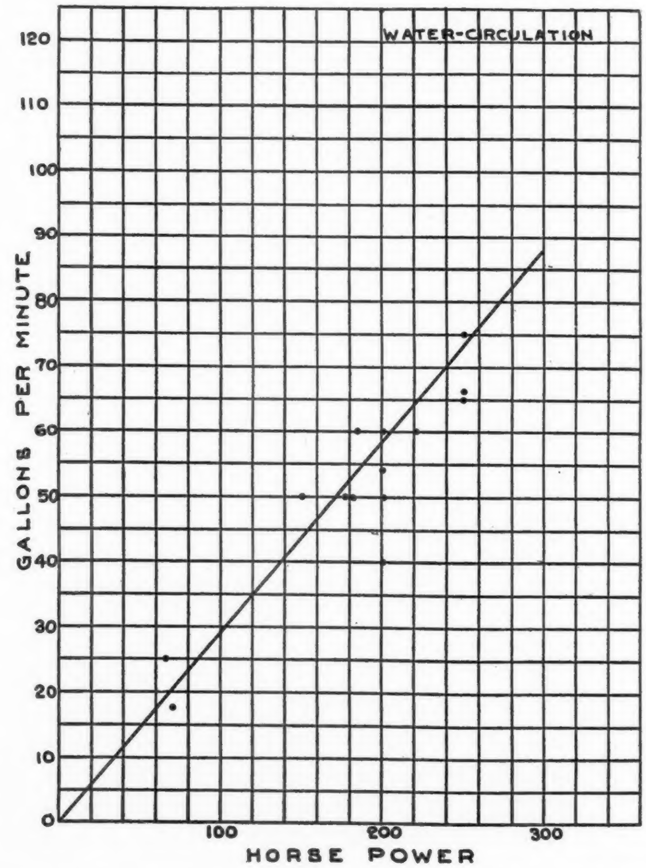


Fig. 5.—Number of gallons of water circulated per minute against engine horsepower

Diesel engines to rail cars and is realizing very satisfactory economies, not only in the cost of fuel per gallon, but in the utilization of this fuel in their engines, securing an unusually high mileage per gallon.

Performance data—There seems to be considerable variation in the methods of recording performance on various railroads, especially with respect to the measure of reliability in terms of miles per detention and miles per total failure. The returns of such information have been gone over and the figures which appear to have been arrived at on a comparable basis are shown in Table II.

Maintenance—Inspection—Instruction—Replies regarding the organization used for maintenance and inspection of cars have been rather meager due in some cases to the fact that the use of rail cars is usually not of long standing and that no routine shopping methods have been evolved. In most cases, the repairs are apparently taken care of directly where the cars tie up, while on a few railroads, special shops have been equipped into which rail cars are run for heavy overhaul work. Inspection is usually taken care of by especially qualified gasoline engine men in connection with the local maintenance forces. The instruction of operators in the case of newly-acquired equipment is by the manufacturers' representatives, and thereafter by the gas rail car inspectors or road foremen. It is agreed that a thorough education of personnel and the efficient and smoothly-working organization constitute most important factors of the rail car problem.

Public opinion—The expressed public opinion is almost uniformly favorable, although in the case of some antiquated equip-

ment, which has proved unreliable in service, public opinion has been adverse—or, merely tolerant. It appears that the public is much more favorable toward the large cars which appear more like regular equipment, and in which case the rather rough operation of gears and clutches has been eliminated by the use of electric drives.

Scope of application—The replies to the questionnaires are rather non-committal respecting the possible scope of application of rail cars, and in general refer directly to the present application of rail cars on the respective lines, so that railroads operating only single cars on branch lines express themselves as believing that this is the only suitable application, whereas railroads which have operated large cars with single or multiple trailers in

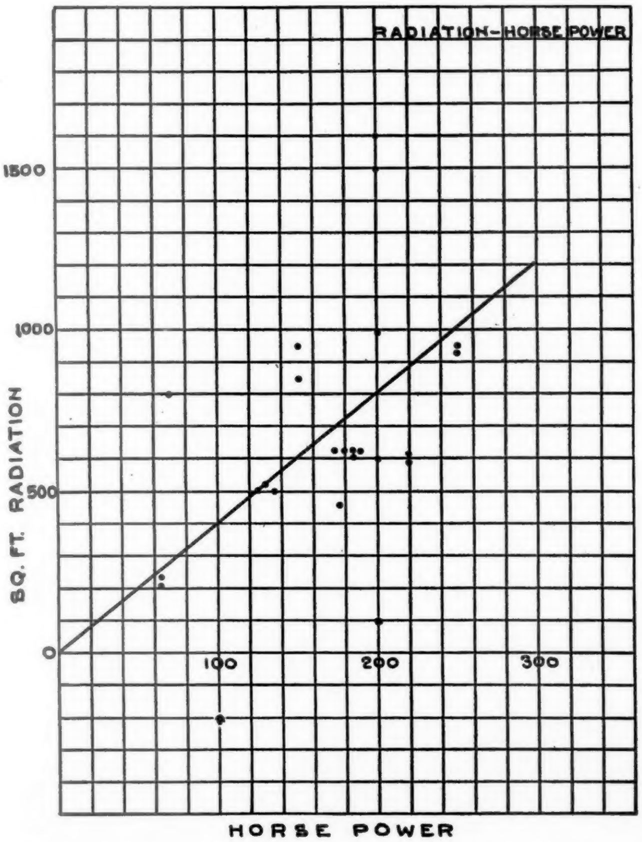


Fig. 6.—Square feet of radiation against horsepower

main-line local service seem to consider this a satisfactory application.

Although in Table I, it is shown that the direct operating expenses of gas rail cars are distinctly less than those of branch line steam service, this does not constitute the entire saving, for by the use of automotive equipment it has frequently been found possible to avoid the expenses due to the maintenance of coaling and water stations, turn tables, ash pits, etc., and in many instances it has permitted the rearrangement of runs and the concentration of facilities in relatively few modern enginehouses and the closing up of small outlying houses, or limiting their use to mere shelters for gasoline equipment. In some other cases, due to the double-end operation of electric cars, the turning of locomotives, and the numerous incidental switching operations have been eliminated permitting economies in forces and shorter terminal layovers. The actual values of these somewhat intangible savings are not easily obtained, but they are not inconsiderable and it is probable that as railroads become more familiar with the possibilities of the rail car they will find increasing opportunities for their benefical and economical use, as there is a larger field for rail cars than that which has been exploited.

This report is signed by C. E. Brooks (chairman), Canadian National; B. N. Lewis, Minneapolis, St. Paul & Sault Ste. Marie; F. P. Pfahler, Seaboard Air Line; F. K. Fildes, Penna.; A. H. Fetters, Union Pacific, and D. L. Bacon, New York, New Haven & Hartford.

Discussion

In discussing the report, Chairman Brooks remarked that he did not believe that the majority of the railroads furnishing information and data to the committee had made a real study of the fuel problem. There were, however, two or three exceptions among the Class I railroads. These roads, he said, have been making a deep study for the past ten years relative to economical fuel consumption and very successful operation had resulted.

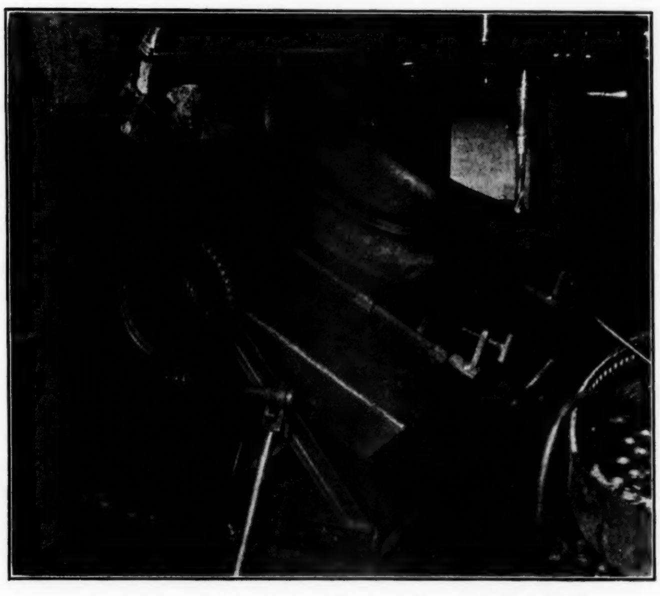
Considerable discussion developed relative to the maintenance cost of the gasoline engine units and also to the vibration which seemed to be a common fault in the majority of rail motor cars. The vibration and engine noise, it was said, does not attract patronage and the discussion indicated a feeling that some method of making a more comfortable car in so far as noise is concerned ought to be given attention.

Chairman Brooks, in commenting on the oil-engine motor cars, indicated that the engine had not yet reached a state of development such that the percentage of serviceability was entirely satisfactory. He called attention, however, to the fact that the Canadian National cars are being operated in black figures and not in red, and that fuel oil costs about 10½ cents a mile less than would gasoline in Canada. He is confident of the ultimate development of a highly efficient, light weight and reasonably cheap oil engine that will meet all of the requirements.

The report was accepted and the committee continued.

Tilting table for radial drill presses

THE tilting table, shown in the illustration, is used in the boiler shop of a large railroad located in the middle west, for drilling holes with a large radial drill in the flanges of sand boxes, domes and other boiler accessories of irregular shape. The table was built in the company shops and is made of heavy boiler plate, suitably braced underneath to provide a stable support.



A tilting table for the boiler shop radial drill

The base is built up of angle and channel irons. The worm gear is operated by means of a ratchet lever secured to the end of the worm shaft. It is of substantial construction to withstand any pressure that may be exerted by the drill at the extreme edge of the table. The table is provided with clamps and also has holes drilled in the top, for the purpose of securing the work either by using the clamps or by bolting direct to the table.

Reports on rules and specifications

Five reports dealing with loading and interchange rules and with specifications affecting large expenditures for material

At every meeting of the Mechanical Division of the American Railway Association four committee reports are presented which deal with rules and specifications affecting the use and maintenance of cars. These are the reports of the Arbitration Committee, Committee on Prices for Labor and Material, the Loading Rules Committee and the Tank Car Committee. In addition to these four reports dealing specifically with car matters, a report of the Committee on Tests for Materials is also a regular feature of the Mechanical Division program.

The changes made in the Interchange Rules this year as set forth in the Report of the Arbitration Committee, were, in the main, for the purpose of clarifying the extent of the rules, standardizing repair methods and extending effective dates set forth in several of the rules.

Of particular interest are the findings of the investigations, made by a sub-committee, pertaining to a recommendation of the Railway Accounting Officers Association that the interchange rules be modified whereby all charges for repairs amounting to 25 cents or less per car be omitted, as it was alleged that the cost of preparing the original record, billing repair card, pricing and rendition of the bill and checking thereof was as great, or perhaps greater, than the average of changes amounting to 25 cents and less. The recommendation of the committee will eliminate many of the smaller items coming under the 25-cent limit.

The activities of the Tank Car Committee during the past year have been influenced by the adoption of specifications for tank cars by the Interstate Commerce Commission and by developments in the chemical industries affecting not only certain important details of existing tank car construction, but involving, as well, radical departures in design. The report covers new specifications and revisions made to existing specifications.

The most important change made in the report of Loading Rules pertains to the rule covering the loading of machinery which has been completely revised to provide for loading on skids.

Report of arbitration committee

T. W. Demarest
Chairman

During the year Cases 1477 to 1532, inclusive, have been decided and copies sent to the members. A copy of these decisions is made part of this report. A vote of concurrence in the decisions is respectfully requested by the committee.

As explained in the 1926 report, there was referred to the committee a recommendation of the Railway Accounting Officers' Association that the Interchange Rules be modified, whereby all charges for repairs amounting to 25 cents and less per car be omitted, and in support of this recommendation it was alleged that the cost of preparing the original record, billing repair card, pricing and rendition of bill and checking thereof, was as great or perhaps greater than the average of charges amounting to 25 cents and less.

The sub-committee appointed to make a study of the situation has completed the investigation and its report is printed as Exhibit A. This report developed that the total average cost of rendering and checking bills for charges amounting to 25 cents and less, based on studies on twelve representative railroads in the United States and Canada, amounted to 7.1 cents per card. The committee, therefore, has recommended the addition of five of the smaller items of repairs to Rule 108, for which no labor or material charge may be made, and which, if adopted, will eliminate approximately 46 percent of the repair cards now being issued for repairs amounting to 25 cents and less. The total labor and material charge for the items so designated is less than or approximately equal to the cost of rendering and checking the bills.

The sub-committee also investigated the practice of writing billing repair cards at the car, which practice has been under trial on several railroads for various periods of time. As this system appears practical and economical, the committee has recommended a modification of Rule 7 to provide for this plan as an optional arrangement.

Attention is again called to the fact that the Arbitration Committee will not consider questions under the Rules of Interchange unless submitted in the form of arbitration cases as per Rule 123.

Freight car rules

All recommendations for changes in the Rules of Interchange submitted by members, railroad clubs, private car owners, etc., have been carefully considered by the committee and, where approved, changes have been recommended.

Rule 2

The committee recommends that the second paragraph of Section (c) of this rule be modified as follows:

Proposed form—Cars equipped with A.R.A. standard axles may be loaded to *limits* shown in Column "A" of Rule 86 (which is the total weight of car and lading for the respective capacities given), *except where stenciled load limit has been reduced, as indicated by star (*) symbol per Rule 30, account structural limitations on car body or trucks.*

Reason—The limits referred to properly apply to all cars equipped with A.R.A. standard axles, except where the load limits have been reduced on account of structural limitations on car body or trucks.

The committee recommends that Paragraph (2) of Section (f) of this rule be modified to read *"metal* transoms."

Reason—To exclude wooden transoms.

Rule 3

The committee recommends that the effective date of the fourth paragraph of Section (a) be extended to January 1, 1929.

The committee recommends that the effective date of the sixth paragraph of Section (b) be extended to January 1, 1929.

The committee recommends that the effective date of the third paragraph of Section (c) be extended to January 1, 1929.

Reason—The present situation justifies these extensions.

The committee recommends that a new fifth paragraph be added to Section (c) of this rule, as follows:

Proposed form.—(5) *Coupler operating levers connected direct with coupler lock or lift without the use of links, clevises, clevis pins or chains, shall be applied to all cars when replacing broken or missing levers where practicable, or when cars receive general repairs.*

Reason—To provide for standardizing of the uncoupling rigging on existing cars, corresponding with the requirements for new cars.

The committee recommends that the effective date of Section (f) be extended to January 1, 1929, as the situation justifies this extension.

The committee recommends that effective August 1, 1927, the third paragraph of Section (s) of this rule be modified, as follows:

Proposed form—(3) Stenciling: Light weight and capacity in pounds, as provided in Rules 30 and 86, required on all cars. From owners. Tank cars *and live poultry cars* shall be re-weighed and remarked by the *owners* or their authorized representatives.

Reason—Account change in Rule 30.

The committee recommends that a new paragraph be added to Section (t) of this rule, as follows:

"Truck side frames with integral journal boxes, conforming to A.R.A. recommended practice, required on all cars built on or after July 1, 1928. From owner."

Reason—As recommended by the General Committee.

The committee recommends that effective August 1, 1927, the second paragraph of Section (t) of this rule be modified, as follows:

Proposed form—(2) Tank cars (empty or loaded): The dome covers, outlet valve reducers, outlet valve caps, outlet valve cap pipe plugs, heater coil inlet and outlet pipe caps or end plugs and plugs or caps of other openings, must be securely in their proper places; *except empty tank cars used in "Asphalt," "Fuel Oil," or "Lubricating Oil" service, and so stenciled, may be interchanged with steam inlet and outlet caps hanging by their chain or other attachments.*

Reason—To prevent heater pipes from bursting due to condensation freezing, on cars used in service referred to.

The committee recommends that the effective date of the third paragraph of Section (t) be extended to January 1, 1929, and the paragraph modified as follows:

Proposed form—(3) Tank cars formerly equipped with head block anchorage will not be accepted after January 1, 1929, *unless* tank heads, *if* dented or depressed 1½ *inches or more* due to damage from contact with head blocks, *have been reinforced by steel shoes as required by* Section 5 of Classes I and II Tank Car Specifications. In interchange.

Reason—As recommended by the Committee on Tank Cars. The present situation justifies the extension of effective date.

The committee recommends that the effective date of the fifth paragraph of Section (t) be extended to January 1, 1929.

The committee recommends that the effective date of the second paragraph of Section (u) be extended to January 1, 1930.

Rule 4

The committee emphasizes the importance of notifying inspectors in interchange districts in all cases of defects cardable in interchange where it is impracticable to apply the regular defect card before the car is moved to the interchange district.

Rule 7

The committee recommends that first paragraph of this rule be modified, as follows:

Proposed form—When repairs are made to a foreign car (except as otherwise provided in Rule 108), or to any car on the authority of a defect card, a form shown on page 254 shall be used for original record of repairs, from which the billing repair card shall be made; *or, in lieu thereof, the original record of repairs may be written directly on the billing repair card at the car, in which event carbon copy of such billing repair card will serve the purpose of original record of repairs as well as record repair card.*

Reason—To make optional the plan of preparing billing repair cards at the car.

Rule 17

The committee recommends that first paragraph of Section (c) of this rule be modified, as follows:

Proposed form—(c) In replacing couplers, the dimensions of shank and butt *for A.R.A. type D, former A.R.A. standard or temporary standard* couplers, standard to the car, must be maintained, except that 9⅛ in. butt may be substituted for 6½ in. butt when used with A.R.A. standard yoke in substitution for non-A.R.A. standard yoke.

Reason—To clarify the intent.

The committee recommends that last paragraph and interpretation of Rule 18 be relocated as new last paragraph of Section (c) of this rule, and modified, as follows:

Proposed form—In replacing former A. R. A. standard couplers, if another make is applied to the car, the uncoupling arrangement shall be made operative at the expense of repairing line; except that coupler operating levers connected direct with coupler lock or lift without the use of links. clevises. clevis pins or chains, may be applied at expense of car owner, when replacing broken or missing levers connected with clevises, links or chains, or when cars receive general repairs; also, when uncoupling arrangement is changed account first application D coupler. The top lift or bottom lift type coupler whichever is standard to the car, shall be maintained.

Reason—To provide for standardizing of the uncoupling rigging on existing cars, corresponding with the requirements for new cars.

The committee has approved the following new interpretations of this rule:

(23) Q—In connection with Section (a), is the substitution of an A.R.A. standard wrought-iron riveted yoke in replacement of a broken cast-steel key yoke considered wrong repairs?

A—Such substitution impairs the strength of the original construction and, therefore, constitutes wrong repairs subject to Rule 88; defect card to be issued for labor only in cases of owner's responsibility.

(24) Q—In connection with the substitution of a wrought-iron yoke for a cast-steel yoke which is not defective, in case riveted yoke coupler is applied on account of an A.R.A. Type D coupler defective, is the repairing line justified in allowing only scrap credit for the cast-steel yoke removed?

A—No.

Reason—Inasmuch as the association has recognized the key design of yoke for new equipment, with no alternative method, it should be protected.

Rule 18

The committee recommends that the last paragraph and interpretation under this rule be eliminated.

Reason—Account of relocating as last paragraph of Section (c) of Rule 17.

Rule 19

The committee recommends that a new item be added to this rule, as follows:

"Plain handle for angle cock."

Reason—The self-locking handle should be made mandatory in repairs as a safety device.

Rule 23

The attention of the committee has been called to the failure of railroads welding cast-steel side frames, to properly anneal them in accordance with the requirements of Rule 23. The present rules permit the welding of side frames in accordance with the regulations contained in Rule 23, regardless of the design of frame, some of which are known to be weak and prone to failure.

It is recommended that the committee on Autogenous and Electric Welding give consideration to the question of prohibiting the welding of side frames.

Rule 30

The committee recommends that a sentence be added to Paragraph (2) of Section (a), that the note under Section (a) and a sentence be added to Section (c) of this rule, effective August 1, 1927, as follows:

Proposed form—(a) (2) *This requirement does not apply to tank cars or live poultry cars.*

(a) Note—Tank cars *and live poultry cars* shall be weighed and stenciled by the *owners* only, or by authorized representatives of the *owners*. This paragraph does not apply to tank cars *or live poultry cars.*

Reason—The load limit markings are unnecessary for tank cars and live poultry cars.

The committee recommends that Section (g) of this rule be modified, effective August 1, 1927, as follows:

Proposed form—(g) When a car is re-weighed and remarked the car owner must be promptly notified of the old and *of* the new *light* weights *and load limits,* with place and date. The proper officer to whom these reports should be made will be designated in The Official Railway Equipment Register.

Reason—To conform to Car Service Rule 11.

The committee recommends that first note following Section (h) of this rule be modified, effective August 1, 1927, as follows:

Proposed form—Note—All new cars *and* all cars receiving repairs on owner's rails, which require re-light weighing, shall be stenciled with load limit markings, *except tank cars and live poultry cars.*

Reason—The so-called "rebuilt car" is not recognized in the A. R. A. rules. Load limit markings are unnecessary for tank cars and live poultry cars.

The committee recommends that effective August 1, 1927, the completion date of the second note following Section (h) of this rule be extended to January 1, 1929.

Reason—A time allowance for load limit markings of eight months from the original three year limit is considered ample for the general proposition.

Rule 32

The committee recommends that first paragraph of this rule be modified, as follows:

Proposed form—Dome covers, discharge valve caps, safety valves or *safety vents* missing from tank cars.

Reason—The safety vents should have the same protection as safety valves.

The committee recommends that fifth paragraph of this rule be modified, as follows:

Proposed form—Removing or cutting out parts of car to facilitate loading or unloading, *except in the case of holes bored, drilled or punched in sides, ends or bottoms of gondola cars for the purpose of securing lading in accordance with the Loading Rules.*

Reason—The handling line should not be penalized for such damage when occasioned by compliance with the Loading Rules.

The committee recommends that Section (k) of this rule be modified, as follows:

Proposed form—(k) Fire damage: *Handling line is responsible for interior as well as exterior fire damage occurring while car is in its possession; otherwise delivering line shall be responsible for only that portion of interior damage as is discernible from an exterior inspection. In the event car is empty the interchange inspection shall be on same basis as though car was loaded insofar as the interior damage is concerned.*

Accordingly, present Interpretations Nos. 1 and 12 of this rule will be eliminated.

Reason—To clarify the intent of the rules as to the responsibility for interior fire damage.

The committee has approved new interpretation of this rule, as follows:

(17) Q.—Arbitration Decision No. 1505 holds the handling line responsible for Rule 44 combination damage where it was the first car struck. Would the responsibility apply to any other cars damaged to the same extent?

A.—If the first, second or third car of either standing or moving cut is damaged to the extent of Rule 44 combination (except as otherwise provided in Section 1 in the case of wood underframe car) the handling line will be responsible.

Reason—It is felt that the responsibility should be on above basis.

Rule 33

The committee recommends that the first paragraph of this rule be modified, as follows:

Proposed form—Owners will be responsible for the expense of repairs to safety appliances where not involved with other delivering line damage, except *damage to safety appliances* on tank cars when *due to any of the provisions of Rule* 32.

The committee also suggests that Interpretation No. 2 to this rule be modified, as follows:

Proposed form—(2) Q.—Are repairs to safety appliances chargeable to car owner on car derailed, cornered, sideswiped, or subjected to any other Rule 32 condition where there is no other delivering line damage on the car, it being understood that damage *to safety appliance* on tank cars due to *any of the conditions of Rule* 32 is *not* chargeable to owner?

A.—In such cases owners are responsible for the expense of repairs to running boards, handholds, ladders, ladder treads, sill steps, brake shafts, brake step boards, uncoupling levers and parts of these items where not involved with other delivering line damage, except that damage to safety appliances on tank cars *due to any of the conditions of Rule 32* is a responsibility of the handling line.

Reason—The rule now protects tank cars against damage to safety appliances when due to cornering or sideswiping on account of special construction. The same principle should apply to other conditions of Rule 32.

Rule 44

The committee recommends that Section (5) of this rule be modified, as follows:

Proposed form—(5) Two steel center *sills* on *all-steel underframe* cars having *but* two longitudinal sills.

Reason—To extend protection to other cars similarly constructed.

Rule 49

The committee recommends that Section (c) of this rule be modified, as follows:

Proposed form—(c) Steel box cars not equipped with cardboards for special explosives and other placards, as required by the I. C. C. Same to be located on side doors and both ends of car. Size to be not less than 16 by 24 in.

Reason—To conform to A. R. A. recommended practice.

Rule 57

The committee recommends that cut shown on Page 93 for airbrake hose label be revised to show the A. R. A. monogram in horizontal position instead of vertical.

Reason—To conform to A. R. A. standard design.

Rule 60

The committee recommends that, effective August 1, 1927, Interpretation No. 1 of this rule be eliminated on account of being covered in Interpretation No. 4; also, that the present Interpretation No. 4 be relocated as new Interpretation No. 1 and last old paragraph of the answer be eliminated.

Reason—Account of being covered in the revised Interpretation No. 2. The committee also recommends that effective August 1, 1927, Interpretation No. 2, to this rule be modified, as follows:

Proposed form—(2) Q.—In case air brakes are cleaned within nine months from date of last previous cleaning, may owner be billed for the work?

A.—*Yes, in the event of air brakes being inoperative, except as follows:*

If *the* brakes are cleaned *by* same road within sixty days from date of *the previous* cleaning, charge for *such* subsequent cleaning is not permissible, regardless of whether the previous cleaning was charged.

If the brakes are cleaned on different roads or private car lines within sixty days from date of previous cleaning, the entire charge for such previous cleaning shall be withdrawn, except where the last cleaning was occasioned by delivering line defects. Where the last cleaning is done by car owner, joint evidence, per Rule 12 shall be used to establish the defective condition which occasioned such cleaning. These provisions apply when the subsequent cleaning was done on or after August 1, 1927.

Reason—A road performing this work should be responsible for it for a period of sixty days.

Rule 66

The committee recommends that the effective date which makes owners responsible for periodical repacking of journal boxes be extended to May 1, 1928.

Reason—As authorized by the general committee and announced in Circular D. V.-505, issued April 18, 1927.

Rule 86

The committee recommends that the effective date of the third paragraph of Section (b) of this rule be extended to January 1, 1929.

Reason—The present situation justifies this extension.

The committee recommends that second paragraph of Section (f) of this rule be modified, as follows:

Proposed form—See Rule 2, paragraph (c). Cars equipped with A. R. A. Standard axles may be loaded to *limits* shown in Column "A" (which is the total weight of car and lading for the respective capacities given), *except where stenciled load limit has been reduced, as indicated by star* (*) *symbol per Rule* 30, *account structural limitations on car body or trucks.*

Reason—To conform to the change in Rule 2, Section (c).

Rule 98

The committee recommends that paragraphs two and four of Section (b) of this rule be modified, and that paragraph six of Section (b) be made new paragraphs six and seven and modified, as follows:

Proposed form—2. In the case of cut journal, where one or both wheels are condemned account owner's defect, if new axle and new wheels are applied, charge against car owner shall be confined to net value of the new wheels, except as otherwise provided in Rule 86, Section (b), second paragraph. In such case if *one wheel is condemned account owner's defect and* mate wheel is condemned by remount gage, per Rule 82, renewal of *both wheels* shall be made at expense of *car owner.*

4. If repairs are made by other than car owner on authority of defect card bill on such defect card shall be on basis of material actually applied and removed, except insofar as owner's defects are otherwise provided for in paragraphs 2, 3, 6 *and* 7.

6. Where car owner removes a scrap axle on authority of defect card, charge shall be confined to difference in value between the new or second-hand axle applied and scrap axle removed, including wheel condemned by remount gage, per Rule 82, *except where mate wheel is condemned account owner's defect, in which case the owner shall assume the expense of renewal of both wheels.* Rule 65 also applies.

Proposed form—7. Where car owner removes a scrap wheel on authority of defect card, charge shall be confined to difference in value between the new or second-hand wheel applied and scrap wheel removed, including mate wheel condemned by remount gage, per Rule 82, or axle condemned by remount limit per Section (c) of Rule 86. Rule 65 also applies.

Reason—The car owner should reasonably assume the expense of renewing both wheels when one of them is renewed on ac-

count of owner's defect and the mate wheel on account of the remount gage.

The committee has approved the following new interpretation:

(10) Q.—Where wheels are applied to a foreign car (regardless of responsibility) and subsequently removed within a short period of time on account of the conditions of wear, has the car owner any redress from the road making previous application?

A.—If the same pair of wheels is removed on any road or private car line within sixty days from the date of previous application, due to worn through the chill, worn flange or tread worn hollow, the initial charge (for the wheels, axle, brasses, etc., and labor) shall be withdrawn in case of owner's responsibility for such previous application; in case no bill was made against the car owner for the previous application, the car owner may render a counterbill against the road which made the previous application, for the expense of the subsequent application.

Reason—It is considered that second-hand wheels should give at least sixty days service insofar as such conditions of wear are concerned.

Rule 104

The committee recommends that the first two paragraphs of this rule be modified, as follows:

Proposed form—Second-hand A.R.A. *type D* couplers or parts *of same* shall be charged and credited at 75 per cent of value new. Credit shall be allowed for all parts of such couplers.

Second-hand former standard or temporary standard couplers or parts of same shall be charged and credited at 50 per cent of value new. Credit shall be confined to the body, lock, knuckle and knuckle pin.

When new coupler is applied it shall be so charged whether or not it is of same make as that removed.

The committee also recommends that Items 132 and 133 of Rule 101 be revised to exclude reference to second-hand bodies.

Reason—The growing obsolescence of the former standards and parts justifies reduced prices and credits for them.

Rule 108

The committee recommends the addition of the following items to this rule, for which no labor charge may be made:

Sill step braces or supports (tightened or straightened on car).

Ladders and ladder supports (tightened or straightened on car).

Adjusting lock details of couplers.

Reason—It is desirable to include these items.

The committee also recommends the addition of the following items to this rule, for which no labor or material charge may be made:

Air hose gaskets, except as included in charge for complete hose applied.

Brake shoe keys, under all conditions.

Release valve rod and cotter, under all conditions.

Spring cotters or split keys, under all conditions.

Wood screws (other than lag screws), except where six or more are applied.

Reason—To eliminate preparation of car repair records and bills where the charge for the item does not justify such expense.

Rule 120

The committee recommends that the repair limits for labor and under Section (b) of this rule be reduced approximately 33 per cent and exclude truck repairs.

Reason—In order to further restrict extensive repairs to cars without authority of owner.

Passenger car rules of interchange

Rules 7 and 15

The committee recommends that Section (a) of Passenger Rule 15 be relocated as new Section (j) of Passenger Rule 7 and modified, as follows:

Proposed form—Rule 7. (j) Brakes must be in working order. Brake cylinders, slack adjusters, triple valves, control valves and high speed reducing valves *not* cleaned, oiled and tested within *the last* twelve months, *as shown by the Standard Markings.* The place, month, day and year of last cleaning and oiling and the initials or name of road *to be* stenciled with white paint in a suitable location for visual inspection. Dirt collectors and strainers must be cleaned at time of cleaning triple valves or control valves.

Reason—To clarify the intent and relocate the rule in the proper place.

Rule 8

The committee recommends that Item 4 of Section (a) of Passenger Rule 8 be modified, as follows:

Proposed form—(4) Impact *in switching, except damage to couplers and attachments, buffers and diaphragm face plates or parts thereof.*

Reason—To definitely indicate the responsibility of the handling line for cars handled in switching.

The report is signed by T. W. Demarest (chairman), Penna.; J. E. O'Brien (vice-chairman), Seaboard Air Line; F. W. Brazier, N. Y. C.; J. J. Hennessey, C. M. & St. P.; J. Coleman, Canadian National; H. L. Shipman, A. T. & S. F.; G. F. Laughlin, Armour Car Lines, and Thos. Beaghen, Jr., Mexican Petroleum Corporation

Discussion

In presenting the report, the chairman discussed at length the factors that finally led the committee to recommend that on all new cars built after July 1, 1928, intergral cast steel side frames should be used. This recommendation was made to improve safety and economy. The two principal causes of train accidents, he said, are draft gear attachments and draft gear members, and the other the failure of the truck members. The Type D coupler today is ahead of the methods of attaching it to the car, and in some cases, of those members to which the draft attachments are tied. The three major causes of truck failure are arch bars, brake beams and wheels, he said, and the arch bar truck is only a reasonable structure so long as everything is tight. He made the point that if locomotives can be prepared to move from 500 to 700 miles on a continuous run, there is no reason why a freight car can not be made to produce the same mileage without continuous stopping of the car at yards for inspection and repair work.

The report was accepted.

Report on specifications and tests for materials

F. M. Waring
Chairman

This report covers the work during the past year that has been brought to a conclusion. Other subjects on which no final decision has been reached, but which are being actively pursued, are:

- Carbon vanadium steel forgings,
- Springs,
- Chain,
- Copper tubing,
- Malleable iron castings,
- Non metallic inclusions in steel for forgings and castings,
- Gas and oxygen hose,
- Lumber, in collaboration with committee on Car Construction.

The committee recommends that the following be submitted to letter ballot for approval.

Revision of standard specifications

Specifications for air brake hose gaskets: These specifications have been revised to include sketch of gasket and table of tolerances as revised by the committee on Brakes and Brake Equipment in their 1926 report. (See Daily *Railway Age*, June 12, 1926.)

Specifications for air brake hose gaskets

Change Sec. 7 to read:

7. *Dimensions.*—All gaskets shall conform to the nominal dimensions and tolerance shown in Fig. 1. All gaskets shall be uniform in size and section.

Fig. 1 to be revised.

Revision of recommended practice specifications

(a) In the specifications for wrapped air hose, braided air hose, steam hose, and wrapped cold water hose, the pressure tests have been changed from a momentary maximum to a lower pressure held for 10 minutes. It is believed that this holding test is of more value for developing defects in the hose. Also standard inspection and rejection clauses have been added to the above specifications.

(b) In Specifications for fire hose and tender tank hose, standard inspection and rejection clauses have been added.

(A) 1—SPECIFICATIONS FOR WRAPPED AIR HOSE

Change Sec. 12 to read:

12. *Hydrostatic test*—The remainder of the 2 ft. sample after all other test pieces have been cut therefrom shall withstand a hydrostatic pressure test, as follows, for a period of 10 minutes without bursting or developing defects:

Inside dia. of hose, in.	Pressure, lb. per sq. in.
3/8, 7/16, 1/2, 3/4, 1	625
1 1/4, 1 1/2	550

2—SPECIFICATIONS FOR BRAIDED AIR HOSE

Change Sec. 12 to read:

12. *Hydrostatic test*—The remainder of the 2 ft. sample after all other test pieces have been cut therefrom shall withstand a hydrostatic pressure test, as follows, for a period of 10 minutes without bursting or developing defects:

Inside dia. of hose, in.	Pressure, lb. per sq. in.
3/8	600
7/16	600
1/2	700
3/4	625
1	550
1 1/4	450
1 1/2	375

3—SPECIFICATIONS FOR STEAM HOSE

Change Sec. 12 to read:

12. *Hydrostatic test*—One of the 24 in. test samples shall withstand a hydrostatic pressure test, as follows, for a period of 10 minutes without bursting or developing defects:

Inside dia. of hose, in.	Pressure, lb. per sq. in.
3/8, 1/2, 3/4, 1	700
1 1/4, 1 1/2	650
1 5/8, 1 3/4	625

4—SPECIFICATIONS FOR WRAPPED COLD WATER HOSE

Change Sec. 11 to read:

11. *Hydrostatic test*—The remainder of the 2 ft. sample after all other test pieces have been cut therefrom shall withstand a hydrostatic pressure test, as follows, for a period of 10 minutes without bursting or developing defects:

Inside dia. of hose, in.	Pressure, lb. per sq. in.
1/2, 3/4, 1, 1 1/4, 1 1/2	350
2, 2 1/4, 2 1/2	300
3	250
3 1/2, 4	200

All of the above specifications are to have inspection and rejection clauses added, suitably numbered, as follows:

INSPECTION AND REJECTION

17. *Inspection*—(a) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the hose to permit of arrangement for inspection.

(b) The manufacturer shall afford the inspector, free of charge, all reasonable facilities to satisfy him that the hose is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(c) The purchaser may make the tests to govern the acceptance or rejection of the hose in his own laboratory or elsewhere. Such tests shall be made within 60 days after date of shipment and at the expense of the purchaser.

17. *Rejection*—In case of failure to pass any of the tests or requirements of these specifications, the entire lot of hose represented by the sample or samples shall be rejected. Each length of hose which fails to meet any of the requirements of these specifications shall be rejected.

18. *Rejected sample*—Samples of rejected hose shall be preserved for two weeks from the date of the test report.

(B) SPECIFICATIONS FOR FIRE HOSE, AND SPECIFICATIONS FOR TENDER TANK HOSE

Inspection and rejection clauses, suitably numbered, to be added to these specifications, reading the same as given above.

New recommended practice specification

A new specification for Liquid Paint Drier to be used with linseed oil in freight car paints is shown. The present specifications for Japan drier are to be used with paint reducing oil and unless there is some demand for their retention the committee will probably recommend in its next report that they be dropped from the Manual.

Specifications for liquid paint drier

1. *Scope*—These specifications cover liquid paint drier to be used in conjunction with linseed oil in mixing paint to proper consistency for painting freight equipment cars.

2. *Composition*—The drier shall be composed of lead, manganese or cobalt, or a mixture of any of these elements combined with a suitable fatty oil, with or without resins or "gums," and mineral spirits or turpentine, or a mixture of these solvents.

I. PHYSICAL PROPERTIES AND TESTS

3. *Physical properties*—(a) Appearance: The drier shall be free from sediment and suspended matter.

(b) Color: The drier when mixed with pure raw linseed oil in the proportions of one volume of drier to eight volumes of oil, the resulting mixture shall be no darker than a solution of 6 g. of potassium dichromate in 100 cc. of pure sulphuric acid of specific gravity 1.84.

(c) Flash Point: The flash point shall not be lower than 85 deg. F. when tested in a "Tag" closed-cup tester.

(d) Miscibility Test—The drier shall mix with pure raw linseed oil in the proportions of one volume of drier to 19 volumes of oil without curdling, and no sediment or precipitate should appear in the mixture on standing for two hours.

(e) Elasticity Test—The drier when flowed on a piece of bright sheet metal previously cleaned with benzol, allowed to stand in a vertical position at room temperature for 30 minutes, then hung in an oven and baked for two hours at 212 deg. F. shall leave an elastic film.

4. *Drying test*—The drier when mixed with pure raw linseed oil in the proportions of one volume of drier to 19 volumes of oil, the resulting mixture when flowed on a glass plate, and placed in a vertical position in a well ventilated room, shall dry in not more than 18 hours.

II. PACKING AND MARKING

5. *Packing*—Liquid paint drier shall be put in moisture-proof barrels, cans or packages, according to the railroad company's requirements.

6. *Marking*—The manufacturer shall mark the packages according to the railroad company's requirements.

III. INSPECTION AND REJECTION

7. *Inspection*—(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

(b) The purchaser may make the tests and inspection to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests and inspection shall be made at the expense of the purchaser.

8. *Rejection*—Liquid paint drier represented by samples which fail to conform to the requirements of these specifications will be rejected.

9. *Rejected sample*—Samples tested in accordance with this specification, which represent rejected material, shall be preserved for fourteen days from the date of test report.

The report is signed by F. M. Waring (chairman), Pennsylvania; H. D. Browne, Chicago & North Western; H. G. Burnham, Northern Pacific; E. E. Chapman, Atchison, Topeka & Santa Fe; H. W. Faus, New York Central; A. H. Fetters, Union Pacific; J. H. Gibboney, Norfolk & Western; G. N. Prentiss, Chicago, Milwaukee & St. Paul; F. T. Quinlan, New York, New Haven & Hartford; J. C. Ramage, Southern Railway; T. D. Sedwick, Chicago, Rock Island & Pacific; C. P. Van Gundy, Baltimore & Ohio and Frank Zeleny, Chicago, Burlington & Quincy.

Report on prices for labor and materials

A. E. Calkins
Chairman

In order that the rules may currently provide an equitable basis for inter-road billing, the committee has continued the work of analyzing material, labor and new equipment costs with a view of determining and recommending necessary changes to be made effective August 1, 1927.

All miscellaneous material prices in Rule 101 were rechecked as of March 1, quotations from purchasing agents of eleven large roads, representing 39 per cent of the total freight car ownership in the United States and Canada, indicating that no changes were necessary in new or scrap prices except in the case of brake shoes and steel castings. Downward recommendations are made in these instances.

Air brake material prices remain practically unchanged with the exception of several covering cylinders, which are recommended for adjustment in order to cover parts bearing new piece numbers.

Attention is called to recommended changes in the phrasing of air brake material charges in Rule 101, Items 57-D, 57-E, 57-F, 57-G, 57-H, 57-L, 57-N, 57-P and 57-Q, to clarify the limitations under which the $30.40 or $22.13 net charges may be made for replacement of nonconvertible with K-1, K-2 or convertible triple valves.

A complete table of friction draft gears is being submitted for approval with the view of incorporating information as to the length of gear and pocket for which intended. This is to facilitate checking of repair bills. There are only six instances where the indicated prices for gears reflect changes over those shown in current rules.

Based on data received from nine large representative roads in March, 1927, as to daywork hourly rates paid all employees directly engaged in freight train car repairs, the weighted average hourly rate was found to be $0.6562. Adding the 61.92 per cent overhead heretofore authorized, produced $1.0625 and your committee is recommending the adoption of a labor rate

per hour for freight car repairs of $1.05 effective August 1, 1927, in lieu of the existing rate of $1.00.

Item 172 of Rule 101 and Item 442 of Rule 107 are therefore shown at $1.05 in appended report.

The committee recommends that the $1.15 hourly rate covering the repairs of steel tanks of tank cars, as shown in Item 443 of Rule 107, be increased to $1.20.

The truck combination labor charges, incorporated in Rule 107 on January 1, 1927, have doubtless proved satisfactory to billing clerks and have reduced correspondence.

The 0.1 hr. labor allowance in Item 237, Rule 107, covering nuts or nut locks, has been reduced to $0.07.

New Item 243 is also recommended to cover the painting and stenciling of cars or parts not repaired or renewed, when performed on authority of defect card.

Other miscellaneous changes are recommended in time allowances under Rule 107 where clarification or reduction was justified.

No changes are suggested at this time in the detailed labor allowances of air brake Rule 111 as the result of the recommended 5 per cent change in hourly rate.

Recommendations are made in Rule 112 respecting reproduction pound prices of new freight train cars of all classes in order that supplement of August 1, 1927, may reflect 1926 costs in lieu of 1925 figures shown in the present code. The prices submitted for your approval will be found to follow the trend which occurred in the 1926 market covering total new equipment purchases as compared to 1925. Pound prices for refrigerator, poultry and tank cars are based on figures furnished by representative roads and private lines in the United States and Canada. Prices for all other equipment represent the average selling prices set up by the Presidents' Conference Committee, which secured quotations on the total output of several large United States car manufacturers. Figures from Canadian roads for other than refrigerator cars were not used as their total ownership is less than one-tenth that of the United States carriers and the effect of including it in the weighted average would be negligible.

A slight change is made in phrasing of the rule covering depreciation rates to bring out the fact that the 3 per cent and 5 per cent rates apply to the entire care of those tank cars intended for non-corrosive and corrosive commodities, respectively.

Data submitted by nine large roads indicate that the average hourly rate paid employees engaged in passenger train car repairs in March, 1927, was $0.7072, which, with the addition of 61.92 per cent overhead, produced $1.145. The committee is, therefore, requesting your approval of a labor rate per hour for passenger car repairs of $1.15, in lieu of the $1.10 now authorized in Item 20 of Passenger Car Rule 21, and also an hourly labor rate for lubrication of $0.82, in lieu of the $0.78 now shown in Item 19 of the same rule.

It is the intent of the committee to investigate labor and material costs again in October, and if sufficient change develops necessary revision will be made and inserted in the Rules effective January 1, 1928.

The report is signed by A. E. Calkins (chairman), New York Central; Ira Everett, Lehigh Valley; J. K. Watson, A. T. & S. F.; E. H. Weigman, K. C. S.; T. J. Boring, Penn.; H. H. Harvey, C. B. & Q.; H. H. Boyd, Canadian Pacific, and A. E. Smith, Union Tank Car Company.

The report was accepted.

Report of committee on tank cars

A. G. Trumbull
Chairman

The activities of the Tank Car Committee during the past year have been influenced by the adoption of specifications for tanks by the Interstate Commerce Commission and by developments in the petroleum and chemical industries affecting not only certain important details of existing tank car construction, but involving as well radical departures in design.

As was forecast in the discussion of the committee's report to the association in 1926, the Interstate Commerce Commission in its Docket No. 3666 proposed modifications in the general regulations covering the transportation of explosives and other dangerous articles by freight, under the provisions of which specifications are incorporated covering shipping containers described as "riveted and welded metal and wooden tanks to be mounted on or to form part of a car."

A hearing was held before the Commission on October 27, 1926, which was attended by the chairman of the Tank Car Committee as well as representatives of various interests concerned in the specifications proposed to be adopted.

Following the hearing, the Commission, by formal order dated January 22, 1927, has promulgated amendments to the regulations mentioned whereunder, after July 1, 1927, all tanks must be built which are used for the transportation of inflammable or dangerous articles by freight.

The specifications, in general, follow the provisions of the American Railway Association for tanks effective on March 1, 1926, and as amended by letter ballot of the Association in respect of certain recommendations of the committee incorporated in the 1926 report.

The action of the Commission in adopting these specifications makes necessary a revision of the existing specifications of the American Railway Association in respect of tanks used for the transportation of commodities included in the Commission's regulations for the transportation of explosives and other dangerous articles by freight, but, as to all other articles which may be transported in tank cars and which are not classed as dangerous in the regulations mentioned, transportation may be made only in such tanks as meet the requirements of the Association's specifications either existing or to be adopted.

On due consideration of the subject, the Tank Car Committee has concluded that it will be necessary to continue the publication of the existing specifications because of the fact that so large a number of tanks are now in service which have been built in compliance therewith and with respect to which questions are likely to arise for many years to come. It was concluded, however, that the specifications should be revised in respect of tank cars which may be built after July 1, 1927, and which will be equipped with tanks complying with the Interstate Commerce Commission specifications. In connection with the revision of these specifications which will be undertaken by a sub-committee consisting of Messrs. Lindner and Cooper and the chairman of the committee there will be included specifications for tanks not heretofore included in those issued by the association.

Multiple unit cars

Interest in cars of this description is being stimulated by requirements for the transportation of chemicals, particularly chlorine. The committee, in collaboration with the Car Construction Committee, now has under consideration a car of this description.

Top loading and unloading devices

Owing to the losses which occur through evaporation in handling highly volatile liquids in tank cars equipped with the type of dome closure in general use, there has been increased interest in measures calculated to avoid such losses. The Skelly Oil Company has been particularly active in this field and has contracted for the construction of a number of cars designed for top loading and unloading without opening the dome closure. This is effected by the installation of pipes extending to the bottom of the tank from a recess fitting enclosed in the dome opening. The upper portions of the pipes are provided with suitable valves and with means to permit the attachment of loading and unloading pipes. Under ordinary service conditions, the exposed portions of the pipes and valves are protected by a substantial cover securely fastened in place.

Tank with lock bar joints

In the committee's report of 1926, reference is made to a tank with so-called lock bar joints. This tank has since been completed and mounted and is now in service under appropriate restrictions governing experimental construction.

New specifications

The Class V tank now covered by the specifications was designed for the transportation of inflammable liquids having a vapor pressure not exceeding 20 lb. per sq. in. at a temperature of 100 deg. F. The Class V car was designed for the shipment of compressed liquefied gases having a vapor pressure not exceeding 130 lb. per sq. in. at 70 deg. F. In order to supply the gap between the limits prescribed by these specifications, Class IV-A specifications were drawn. Up to date, however, only 10 cars of this class have been built, all of which were intended for the transportation of ethyl chloride. Owing to developments in the petroleum industry and to the fact that there appears to be no need for additional Class IV-A cars of the original design, the continuation of the original specification no longer appears to be necessary.

Request has been made for approval by the committee of a car to be used for the transportation of liquefied petroleum gases having a vapor pressure of not more than 33 lb. per sq. in. at 70 deg. F. and there are indications that the demand for such a car will increase and since its cost will be substantially less than that of the Class V car, your committee proposes a revision of

the Class IV-A specifications to satisfy this demand. The proposed specifications which will be recommended to the Interstate Commerce Commission for incorporation in the regulations for the transportation of explosives and other dangerous articles by freight will be known as shipping container Specification 104-A Revised, and are presented herewith as Appendix A of this report. This specification is offered for approval by letter ballot.

Revisions in the existing specifications

Service—Class I Cars—On recommendations of the Tank Car Committee, there was submitted to the association in 1926 a proposed amendment to the specifications prohibiting the transportation of inflammable or corrosive products in Class I cars after January 1, 1928. Subsequently, evidence was presented to the committee in substantiation of the statement that this prohibition would affect a considerable number of cars used for the transportation of acid which are rendering satisfactory service and which appear to be suitable for continued use. Under these circumstances, it is recommended that the limitation of the use of the Class I cars be restricted only to those used in the transportation of inflammable products.

Section 7—Bottom outlets—Figure 2 on page 80 of the specifications has been the cause of much confusion on the part of builders of tank cars and as the purpose of this sketch is chiefly to illustrate the outlet, it is proposed that the diagram be revised to cover this feature only, eliminating all the other details including the illustration of the dome, the contained parts thereof and the valve.

Section 20—Safety valves—The revision in the certificate of construction has been the means of directing the attention of the committee to certain desirable changes in the details of the standard 5 in. safety valve, Fig. 9-A, which it is proposed to amend in the following particulars:

(a) Omit the finish mark on the surface of the huddling chamber outside of the valve seat.
(b) Omit the finish mark in the bore of the spring follower requiring 11/16-in. cored hole only.
(c) Require that the valve stem be finished on the 45-deg. face.
(d) Fig. 10-A. Remove the finish mark from that portion of the huddling chamber outside of the valve seat.
(e) Omit the finish mark on that portion of the spring case below the thread and also on the inside below the valve.
(f) Omit the finish mark from the bottom of safety valve collar or flange.

Section 24—Tests of safety valves—Omit paragraph two relating to tests without removal of the valve from the car as this is no longer permissible and also eliminate Fig. 13 showing the apparatus for testing safety valves in place on cars.

Tank heads

Numerous reports have reached the committee of damage occurring to tanks through failure of the heads. Inquiry develops that much study has been given the subject of proper radius of the throat of the tank head flange. A question was also raised regarding the present provisions of the specifications requiring that tank heads shall be dished to a radius of 10 ft. on the concave side.

The committee considers the subject of sufficient importance to warrant a careful investigation of the researches which have been made and consideration of a revision of the existing specification requirements in order to provide for improved design and construction. A subcommittee has been appointed for this purpose.

Safety valves, dome covers and bottom outlet valves

In accordance with the report rendered to the association in 1925, the joint committee of the American Railway Association, American Petroleum Institute and the American Railway Car Institute has organized and named A. E. Smith chairman. The joint committee has done considerable work in connection with the subject of bottom outlets, dome covers and safety valves and has been fortunate in securing for the purpose of this investigation the services of D. V. Stroop of the United States Bureau of Standards. Through this arrangement, sources of information will be open to the committee which would not otherwise be available.

Mr. Stroop has entered upon his duties and a series of tests of various devices will shortly be conducted under the auspices of the joint committee and the immediate direction of Mr. Stroop. It is hoped that all those that are interested in the promotion of the safe transportation of inflammable and dangerous liquids and the solution of the transportation problems incident thereto will submit their devices for the prescribed tests.

Report of subcommittee on bottom discharge outlets

Subcommittee on Bottom Discharge Outlets, since its report of May 6, 1926, has received for consideration four new designs of bottom discharge outlets and three revisions of designs of bottom discharge outlets which had been submitted to the subcommittee prior to that date.

Of the four new designs, only one, that submited by the Midwest Railway Equipment Company, was approved for service trial. It has not as yet been applied to any cars. Of the three revised designs, one was not approved, the other two were approved and are now undergoing service trial. Of these two, the Carr valve, submitted by the Pure Oil Company, should be added to the summary of valves which comply with the specifications effective March 1, 1926, submitted with our 1926 report. The other submitted by the Panhandle Refining Company was previously included in this summary.

Reports covering the performance of valves which have been applied to tank cars and are operating under actual service conditions have not developed any information which would cause the sub-committee to change its previous views in regard to the desirability of requiring the use of valves which are positively held on their seats by some means other than a spring.

It is anticipated that a comparative test of the different designs of bottom discharge outlets now in service, which test is shortly to be made by a joint committee composed of representatives of the American Railway Association, the American Petroleum Institute, and the American Railway Car Institute, under the direction of an associate engineer of the U. S. Bureau of Standards, will enable the Tank Car Committee to recommend to the Interstate Commerce Commission at least several of these designs for inclusion in the Commission's specifications as recognized standard designs of bottom discharge outlets, providing, of course, for the addition to this list from time to time of such designs as similar comparative tests indicate are equally satisfactory.

The report of the subcommittee on Bottom Discharge Outlets is signed by W. E. Cooper (chairman), J. T. St. Clair, and Thomas Beaghen, Jr.

Minority report

A minority report was submitted by A. E. Smith in which he expressed the opinion that paragraph 3 of the sub-committee's report is misleading as the committee is not receiving current reports on the operation of all valves of the type referred to and, therefore, would not be advised of any troubles which might be experienced as shown on previous reports rendered to the committee.

Report of subcommittee on dome covers and safety valves

Safety valves

Your committee in its 1926 report submitted details of the test of a safety valve manufactured by the American Car and Foundry Company. Valves of this type were applied to tank cars of several companies and were to be continued in service for a period of one year and then retested to determine their condition.

Valves as applied by the Union Tank Car Company, Mexican Petroleum Corporation and Texas Company were allowed to remain in service for a period of one year and are now being held awaiting test by the joint committee to be conducted under the direction of D. V. Stroop, at the Philadelphia shops of the Union Tank Car Company. The Union Tank Car Company is also holding six standard A.R.A. valves which were applied new at the same time as the above noted valves, and comparative test is to be made of these valves with those built by the A. C. and F. Co. The valves applied by the Mid-Continent Petroleum Company were removed and we have a report of the yearly test from Mr. Parsons, master car builder, substantially as follows:

All of the valves were removed and placed over test rack and found to be in perfect condition. Five opened at 27 lb. and closed at 25 lb. One opened at 25 lb. and closed at 24 lb. The water test made for leakage showed the first bubble at from 9 to 18 lb., and boiled at from 20 to 24 lb.

Dome covers

In our 1926 report the sub-committee reported on nine types of dome covers and unloading devices undergoing service trial. A general description of the various types was included in the report.

No. 1—Skelly Oil Company—Special loading device.—The results obtained from this and the questionnaires are being followed by W. E. Cooper, Bureau of Explosives.

No. 2—Holmes Universal Gas-tight Dome Cover.—None of this type has been applied.

No. 3—Shanley loading and unloading device.—Approval has been given for trial application to not more than five cars. We have no advice that they have ever been applied.

No. 4—The Humble loading and unloading device submitted by Humble Oil and Refining Company.—This device was applied

to five cars. Information obtained from questionnaires submitted to the sub-committee indicated a favorable performance. No evidence of pressures leaking through the covers and no difficulties experienced in maintaining tight joints or difficulties experienced in unloading; nor were there any repairs necessary due to failure of any parts. The application to 50 additional cars was approved by the subcommittee, September 28, 1926.

No. 5—Dome cover and ring by the American Car and Foundry Co., equipped with safety device.—No information of value was obtained and no further information during the past year has been obtained, and no request for additional applications of this cover have been made.

No. 6—Safety dome cover by the General American Tank Car Corporation.—It is indicated in our 1926 report that this cover had been applied to 225 cars built for the Phillips Petroleum Company, and on information obtained from questionnaires submitted by them, the cover is evidently giving satisfactory service, with the exception of one report received that some of the cars loaded with casing head gasoline, with internal pressure apparent, the cover could be removed while pressure existed in the tank.

No. 7—American Car and Foundry Company hinge type dome cover which opens downward into the dome.—Reports received on this type of cover indicate that further investigation is necessary in connection with the suitability of this cover for cars used in the transportation of casing head gasoline.

No. 8—American Car and Foundry Company hinge type pressure locking dome cover.—We have no advice that authority had ever been granted by the Interstate Commerce Commission for a trial application of this type cover.

No. 9—Closed circuit loading device—Union Tank Car Company.—Authority has been granted for its application to 250 U. T. C. cars. To date we have advice of test application to 122 cars and the results obtained from the service trial are being followed by W. C. Cooper, Bureau of Explosives.

We also have been following the performance of the American Car and Foundry Company self venting pressure locking dome cover screw type. This is an A. R. A. screw type dome cover with internal lift actuated by pressure within the tank which is intended to prevent its removal while pressure exists. While we have ten of these covers in service, no reports have been received which permit an expression of opinion as to the possibilities of this cover for use in casing head gasoline service.

No complaints have been received covering the performance of the A. R. A. fundamental bolted type dome cover which has been applied to a large number of Class III tank cars, and your committee expects shortly to recommend standard type of dome cover for the Class IV cars.

The report of the subcommittee on Dome Covers and Safety Valves is signed by W. C. Lindner, chairman; I. T. St. Clair, Geo. McCormick and A. E. Smith.

Appendix A—Proposed revision of specification No. 104A

1. *Type*—Tanks built under this specification must be cylindrical in form with heads dished convex outward. The tank must be provided with a manhole ring and cover on top of the tank of sufficient diameter to permit access to the interior of the tank and to provide for the proper mounting of inlet, outlet, and safety valves, and a protective housing on the cover. No other opening in the tank is permitted.

The tank, except where it is seated on the bolsters of the car, must be lagged with compressed cork board properly molded to fit, or other material of equivalent heat insulating and shock resisting quality, to a thickness of not less than 4 in. When heater pipes are attached to the exterior of the tank, the thickness of the lagging over each pipe may be reduced to not less than 2 in. A jacket of sheet metal not less than one-eighth inch in thickness, welded or otherwise fastened together, must entirely cover the lagging. Openings through the lagging must be flashed around projections to prevent admission of water. The manhole ring must be so constructed that liquid cannot enter between its wall and the jacket. The tank must be well painted before being lagged and the inside of jacket must be painted before it is applied.

2. *Bursting pressure*—No change, except that the calculated bursting pressure must be not less than 495 lb. per sq. in.

3. *Material*—All plates for tank must be made of open-hearth boiler-plate steel of flange quality. All external projections must be made of materials specified hereinafter. Rivets must be of the same quality as used for steam boilers and other pressure vessels.

4. *Thickness of plates*—The minimum thickness of plates, including thickness of each plate at rivet seams, must be as follows:

Diameter of tanks	Bottom sheets	Shell sheets	Tank heads
87 in. or under	9/16-in.	9/16-in.	13/16-in.
Over 87 to 96 in.	5/8-in.	5/8-in.	7/8-in.

5, 6 and 7. No change.

8. *Calking*—All seams must be calked both inside and outside, except that outside calking of seam formed by attachment of manhole ring is not required.

9. *Expansion dome*—No expansion dome is permitted.

10. *Closure for manhole*—All joints between manhole cover and manhole ring, and between manhole cover and valves mounted thereon, must be made tight against vapor pressure, and to secure this a suitable gasket must be used, except where safety valve screws into manhole cover.

11. *Manhole ring and cover*—The manhole ring must be constructed of cast or pressed steel, having a wall thickness not less than the thickness of the wall of the tank, with a cover of steel plate not less than 2 in. thick, on which is bolted a valve-protecting housing of cast or pressed steel fitted with a steel cover that can be securely closed. The cover must be provided with screened openings over the safety valve. The housing may be provided with openings to permit the connecting of piping with the venting and discharge valves without removal of the housing. The manhole cover must be attached to the manhole ring by through bolts or studs not entering the tank.

12. *Venting and discharge valves*—(a) The venting and discharge valves must be of the flange type, made of material not subject to destruction, by the lading, and must withstand a pressure of 300 lb. per sq. in. without leakage. The valves must be directly bolted to seatings on the manhole cover. Provision must be made for closing the pipe connections of the valves.

(b) The reduction pipes of the discharge valves may be equipped with ball check valves.

13. *Bottom discharge outlets.*—No bottom discharge outlet is permitted.

14. *Safety valve*—(a) The tank must be equipped with one 5-in. safety valve mounted on manhole cover. Valve must have a discharge capacity sufficient to prevent building up of pressure in the tank in excess of 100 lb. per sq. in. should the tank be exposed to fire.

(b) The safety valve must be set to open at a pressure of 60 lb. per sq. in. (For tolerance see paragraph 18 on tests.)

15. *Fixtures and other attachments*—No attachments other than those mounted on the manhole ring and cover, the anchorage, and safety appliances are permitted, except that heater pipes may be attached directly to the exterior of the tank by suitable bands. Safety appliances should preferably be attached to pads on the jacket or to suitable tank bands.

16. *Plugs for openings*—Not required.

17. *Tests of tanks*—Each tank must be tested before being put in service and also at intervals as prescribed in paragraph 19, by completely filling the tank and manhole ring with water, or other liquid having a similar viscosity, of a temperature which must not exceed 100 deg. Fahr. during the test, and applying a minimum pressure of 100 lb. per sq. in. The tank must hold the prescribed pressure for not less than 20 min. without leak or evidence of distress. All rivets, valves, except safety valves, and connections entering the tank must be in place while this test is made. If the jacket and lagging are not removed, a drop in pressure shall be evidence of leakage, and such portion of the jacket and lagging must be removed as may be necessary to locate the leak and make repairs. After the repairs have been made, the tank must again be subjected to the prescribed test.

18. *Tests of safety valves*—No change, except that valve must not leak below 55 lb. pressure. The valve must open at the pressure prescribed in paragraph 14(b), with a tolerance of plus or minus 5 lb.

19. *Retests of tanks and safety valves*—No change, except that tanks and valves must be retested at intervals of not more than two years after the original test.

20. *Marking*—Each tank must be marked as follows:

(a) to (d) inclusive. No change, except that the marking must be I. C. C.-104A and the stenciled marks must be on the jacket.

(e) Water capacity of the tank in pounds stamped plainly and permanently in letters and figures not less than 3/8 in. high into the metal of the tank immediately below the mark specified in paragraph 20(b). This mark must also be stenciled on both sides of the valve protecting housing in letters and figures at least 2 in. high.

21. *Reports*—No change.

The report of the full committee was signed by A. G. Trumbull (chairman), Erie; J. T. St. Clair, Atchison, Topeka and Santa Fe; G. McCormick, Southern Pacific; W. C. Lindner, Penna.; B. W. Dunn, Bureau of Explosives; A. E. Smith, Union Tank Car Company; T. Beaghen, Jr., Mexican Petroleum Company; H. L. Worman, St. Louis-San Francisco; G. E. Tiley, General Chemical Company and C. C. Meadows. Tidal Refining Company.

Discussion

Subsequent to the printing of the report, the committee's attention was invited to the fact that there was a discrepancy in the provisions of the present specifications of Class I, II, III tank cars and those of the Inter-

state Commerce Commission, with respect to the period within which the safety valves are required to be tested. The chairman stated that it was agreed to make the requirement so that tanks and safety valves will be retested in ten years after the original test. The present provisions are that the retest shall be made every two years. *The report was accepted.*

Report of loading rules committee

R. L. Kleine
Chairman

As a result of investigations conducted throughout the year with various types of loads and conferences with the shippers, the committee submits the following recommendations for changes in the rules for approval and submission to letter ballot for adoption by the association.

General rules for loading materials

RULE 4

Proposed form—Cars should be in such condition that the trucks can curve freely and the side-bearing clearance must not exceed 5/16 in. per side-bearing *per truck and must not be less than 1/8 in. per side-bearing per truck.*

Explanation—Limits for side-bearing clearance in this rule have been changed to conform with the A. R. A. Standards, and the maximum of 3/16 in. per side-bearing for loads 10 ft. high or over from the top of the rail has been eliminated. Difficulty is frequently experienced under the present rule in getting down to the 3/16 in. clearance on cars with cast steel truck bolsters and cast steel body bolsters having the center plates and side-bearings cast integral.

RULE 34, FIRST PARAGRAPH

Proposed form—Lading must be secured in closed cars so that it will not come in contact with side doors or roll or shift in transit, and must be so placed in car that there will not be more weight on one side of the car than on the other. *Where the lading is in small units such as bars of bullion or spelter it must be distributed generally over the car floor and if loaded in piles the height of piles must be restricted so that a general distribution of weight is obtained.*

Explanation—A number of derailments have been reported where bars of bullion or spelter have been loaded in piles concentrated along the sides of car and the load became unbalanced due to the piles tipping over.

Group I—Lumber, ties, etc.

RULE 156

Proposed form—It is proposed to omit from this rule the requirement that ends of ties projecting into the doorway must be elevated by a bearing piece laid crosswise of car.

Explanation—Experience has proven that elevation of the ends of the ties projecting into the doorway is not essential to the safety of the load.

Group II—Structural material, plates, etc.

RULE 202, PAGE 82

Proposed form—The following sentence is recommended for addition to this rule: "Lateral shifting or creeping of the plates must be prevented in some effective manner, preferably by placing stakes in the outside stake pockets or by clamping similar to that shown in Fig. 45."

Explanation—Experience with shipments loaded diagonally with one side resting on the car side indicates that these plates will occasionally work out over the side of the car and the proposed requirements for preventing this condition is a necessary safety measure.

RULE 212

Proposed form—Large girders, loaded as shown in Fig. 52, must be secured to carrying car, as per Fig. 49.

The blocking used *must be at least* 8 *in. wide and of sufficient height to keep lading at least* 4 in. above floor or end gates *of idler car, for bearing blocks,* and 2 in. by 8 in. in section for spacing blocks, and 4 in. by 6 in. in section (hardwood) for top clamping pieces. The vertical rods must not be less than 1 in. in diameter, and must, if possible, pass through the blocking and the floor of the car. With loads 24 in. high or over, braces must be added as shown in Fig. 53. If the rivet holes are not available, longitudinal motion must be prevented by using clamps. See Fig. 49.

Explanation—In this rule, which covers single overhanging loads of girders, the dimension for the height of the bearing-blocks has been omitted and a requirement substituted that the height of the bearing-blocks must be sufficient to keep the lading at least 4 in. above the floor or end gate of the idler car. The width of 8 in. for the bearing-blocks has been retained. The dimension for the bearing-blocks shown on Fig. 52 for these loads will be changed accordingly. The change is made to conform with the actual practice in loading.

RULE 230

Proposed form—Long flexible material, like plates, etc., which can not be loaded as shown in Fig. 55, must be loaded on two bearing-pieces, and two or more sliding-pieces as in Figs. 63, 65, 66, 67 and 68. The sliding-pieces must be 4 in. lower than the bearing-pieces *except where the lading will be damaged by permanent deflection, in which case the sliding-pieces may be 2 in. lower than the bearing-pieces.* Sliding-pieces must be equipped with flat metal plates 1/4 in. by 6 in. for loads of 40,000 lb. or less, and 1/2 in. by 6 in. for loads over 40,000 lb. per bearing-piece; 1/4 in. by 6 in. metal sliding plates may be used for loads over 40,000 lb. per bearing-piece if prepared as per sketch "A," secured to their upper sides either with spikes or lag screws at each end. These metal plates are intended to facilitate curving and must be coated with grease before the lading is placed upon them. *The total length of the plates should be such that they project beyond each side of the lading a distance equivalent to the figures shown in last column of the tables under Rule 30, for the respective loads.* The bearing-pieces must be secured to the car in the manner described in General Rules Nos. 26 and 27, and the material must be clamped together in the manner described in Rule 231 to prevent it from shifting.

Note—The metal sliding plates used in connection with twin or triple loads of flexible material should be greased at interchange points to facilitate the curving of the cars.

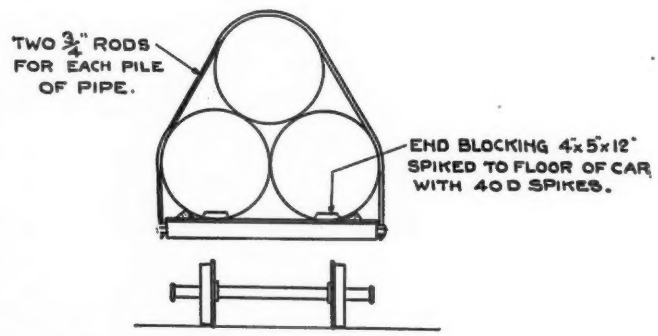


Fig. 81-G—Loading wrought pipe 49 in. to 72 in. in diameter on flat cars

Explanation—This rule has been revised to permit the use of sliding-pieces 2 in. lower than bearing-pieces in place of 4 in., at the shipper's option. The modification was made at the request of a large shipper who received complaints that certain material takes a permanent deflection when sliding-pieces 4 in. lower than the bearing-pieces are used. Trial shipments followed through to destination indicate that this method can be safely followed under the conditions prescribed.

A provision is also added to regulate the length of metal plates on the sliding-pieces to meet the actual requirements based on the length of load and location of bearing-pieces. The present rule requires that the metal plates extend 22 in. beyond each side of lading for all twin and triple loads. By regulating the length of the plates to suit the load, material will be saved the shipper without any decrease in the security of the load on the car.

RULE 249, FIRST PARAGRAPH

Proposed form—There should be not less than three pairs of stakes to each pile, when the material is 23 ft. or less in length, *and the height of the load does not extend over 3 ft. above the top of the car sides. When the pile is more than 3 ft. above the top of the car sides, four pairs of stakes must be used.*

For pipe 23 ft. and less than 30 ft. in length, four pairs of stakes must be used when the pile extends above top of car sides. *Material 30 ft. in length or over, when the load extends above the top of the car sides, must be secured by not less than five pairs of stakes.* The top of each pair of stakes should be held together by not less than six strands equal to three wrappings of good ⅛ in. diameter wire resting on pipe, in addition to any intermediate wiring or dunnage strips for the character of the shipments as provided for in succeeding paragraphs. Intermediate wiring need not be used when load is less than 3 ft. above the car sides.

Note—Boards when used to tie stakes together longitudinally with the side of the car, must be secured to the inside of the stakes and must not, under any circumstances, be nailed to the outside of the stakes.

Explanation—This rule is revised to require five pairs of stakes for pipe 30 ft. or over in length when the load extends above the car sides. Experience of the railroads with numerous shipments of this pipe has demonstrated that the additional stake requirements are necessary.

RULE 251-A

Proposed form—It is proposed to add another figure to this rule (Fig. No. 81-G) to cover wrought pipe 49 in. to 72 in. in diameter loaded on flat cars.

Explanation—A number of shipments of wrought pipe in the above sizes are being offered the railroads and the shippers have requested that a rule be provided to cover them. Shipments in accordance with the proposed method have been followed up in service and found satisfactory.

Group III—Machinery

RULE 309

Proposed form—Heavy machinery such as looms, lathes, planers, boring machines, etc., should, when practicable, have the legs removed and the heavy portion of the machine placed on the floor of the car. Each machine when so loaded, should be blocked by securely bolting or nailing to the floor of the car one 2 in. by 4 in. hardwood strip at each end, full width of the machine, backed up by three 2 in. by 4 in. by 12 in. cleats and one 2 in. by 4 in. cleat on each side one-half the length of the base of the machine, securely nailed to car floor to prevent side shifting.

When such machinery is loaded resting on legs, the machine should be supported by skids placed under the legs and the legs secured to the skids by bolts, lag screws, or cleats, and one 2 in. by 4 in. cleat on each side one-half the length of the skid, securely nailed to the car floor to prevent side shifting, and in addition, two 2 in. by 4 in. braces should extend to each end from the skids to the heavy portion of the machine, these braces to be backed up by one piece, 2 in. by 4 in. extending across the skids. The top of the machine should be securely braced at each end with two 4 in. by 4 in. hardwood braces bolted or otherwise securely fastened to the body of the machine, the braces extending to the car floor and securely nailed to the floor, backed up by cleats. In no case should the legs or skids be secured to the car floor. See Fig. 108-A.

If the end braces cannot be efficiently employed, the top of the machine should be secured at each end by means of a horizontal beam not less than 2 in. by 6 in. running across the car and fastened securely to the sides of car with suitable blocking. See Fig. 108-B.

The legs when removed from such machinery must be crated.

Light machinery, when practicable, should be crated, the legs removed and secured in the same crate. Where the legs cannot be removed, such machinery will be loaded in the same manner specified for heavy machinery with the exception that a 2 in. by 4 in. end bracing will be permissible in lieu of 4 in. by 4 in. as specified.

Note—Top heavy machinery must be securely tied or braced to prevent toppling over.

Explanation—Rule 309 covering the loading of machinery has been completely revised to provide for loading on skids. The present rule has proven inadequate for shipments of this character.

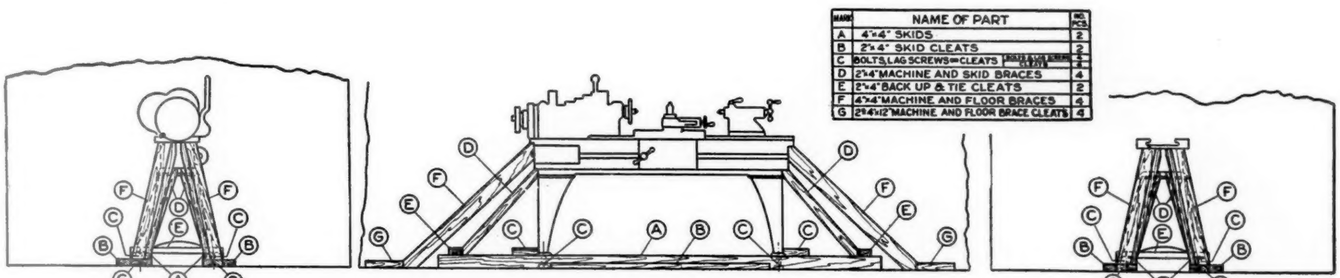


Fig. 108-A—Manner of loading looms, lathes, planers, boring machines, etc., in box, gondola, or flat cars

Group IV—Concrete pipes, brick, etc.

RULE 400

Proposed form—The manner of securing concrete culvert pipe loaded on flat cars; pipe loaded on its side should be secured as per Figs. 109, 109-A or 109-B, the method shown on Fig. 109-B to be followed for pipe loaded crosswise of car, when cars are not equipped with end stakes pockets. *Pipe loaded on end should be secured as per Fig. 110, and where the diameter exceeds 48 in. the pipe may be placed on the floor with the bell end upward.*

Explanation—The rule has been modified to permit concrete culvert pipe over 48 in. in diameter to be loaded on the end with the bell end upward, whereas under the present rule, all pipe loaded on end has the bell on the floor.

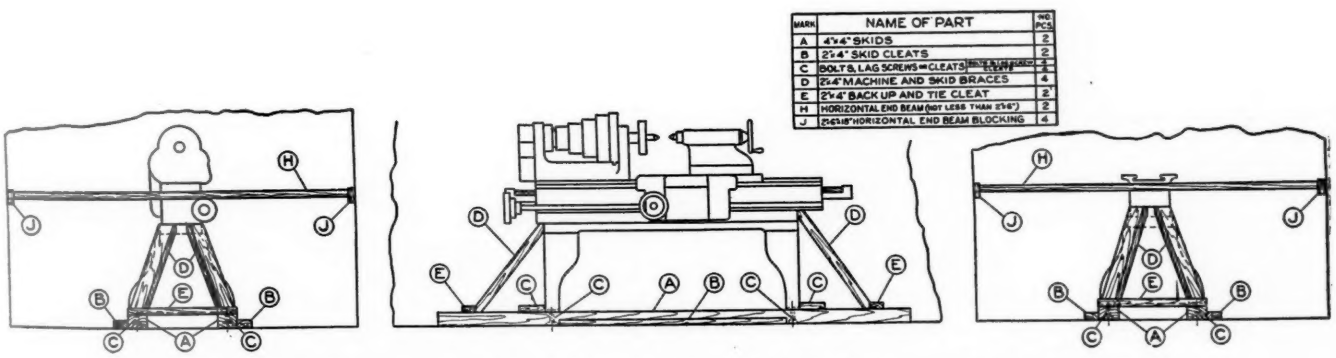


Fig. 108-B—Manner of loading light and heavy machinery in box, gondola, or flat cars

RULE 400, SECOND PARAGRAPH

Proposed form—Pipe 12 in. to *and including* 32 in. in diameter to be loaded in pyramidal form as per Figs. 110-A and 110-B.

Explanation—The wording has been changed to clarify the intent of the rule, making it clear to the shipper that 32 in. diameter pipe is included in the sizes to be loaded in pyramidal form.

Rule 410

Proposed form—First Paragraph: It is proposed to insert the words "flat cars" in the first line so as to confine the paragraph to flat car loading.

Third Paragraph: It is proposed to modify the first sentence to read as follows: "Gondola cars are preferable for such shipments *and when used, no blocking is necessary,* but if flat cars are used, the lading should be placed at least 18 in. back of the end of the car."

Explanation—The wording of these two paragraphs is changed to clarify the intent of the rules in regard to methods of loading large stone on gondola cars as compared with flat cars.

Side stake pockets for flat cars

It has come to the attention of the committee that a number of flat cars suitable for twin shipments have side stake pockets with the opening considerably less than the A. R. A. recommended practice of 4 in. wide by 5 in. deep. These under size stake pockets, for example 3 in. wide and 3¼ in. deep, necessitate so much trimming down of the side stakes that the stakes are greatly weakened and frequently fail in service at this point. This applies particularly to green saplings where the outside wood is trimmed away. To overcome this trouble the following recommendation is submitted.

Recommendation—Add the following paragraph to Interchange Rule 3 (f)—"Flat cars suitable for twin loads should have stake pockets 4 in. wide by 5 in. deep. In interchange."

This report is signed by R. L. Kleine (chairman), Penn.; R. H. Dyer, N. & W.; E. J. Robertson, M. St. P. & S. Ste. Marie; Samuel Lynn, P. & L. E.; G. R. Lovejoy, Detroit Terminal; T. O. Sechrist, L. & N.; C. J. Nelson, Chicago Car Interchange Bureau, and R. B. Rasbridge, Reading.

Discussion

After the report was printed the chairman said that several suggestions were received, the first pertaining to the wording of Rule 4, suggesting that it be changed to correspond with the A. R. A. Manual, Section C, Page 3. The paragraph should preferably be worded thus: "Rule 4. Cars should be in such condition that the trucks can curve freely and the side-bearing clearance must not exceed an average of 5/16 in. per side-bearing per truck and must not be less than an average of ⅛ in. per side-bearing per truck." The committee agreed to change this rule to conform to the A. R. A. manual. The second suggestion pertained to Rule 34 in that the underlined portion should contain specific directions that the lading, such as bars of bullion or spelter, be anchored so that they will not move en route. The committee did not agree to this suggestion. Another suggestion was made that page 13, last item, which contains a recommendation to interchange Rule 3, section F, amended to require: "Flat cars suitable for twin loads should have stake pockets 4 in. wide by 5 in. deep. In Interchange." It was agreed that such an amendment would be rather drastic and should not be incorporated without giving some extension of time to allow the car owners to comply.

A suggestion was made that each portion of the rules be written complete in place of being required to refer over to certain general rules that also apply to the rules governing the loading of commodities listed under the different headings. The chairman of the committee agreed that the point was well taken, but explained that there are certain difficulties in the way of carrying out the suggestion as there are certain general rules which must be followed in connection with the detailed rule covering a particular commodity. While it is not impossible to repeat each of the general rules under the individual headings, it would make a book, either two or three times the size of the present book. He stated that the committee will be glad to consider the suggestion and report to the next convention to decide if it is desirable to make any change in the present make-up of the manual.

The report was accepted and referred to a letter ballot.

Design and construction of cars

Proposed standard stock cars—Single plate, re-inforced flanged cast iron wheels widely used

During the meeting of the Mechanical Division of the American Railway Association, four reports and two papers were submitted dealing with the design, construction and maintenance of freight and passenger cars. The most voluminous report was that of the Committee on Car Design and Construction in which some definite recommendations were submitted for adoption by the association. The more important proposed standards submitted are a uniform stenciling of grain lines in box cars; a modified design of hatch plugs for refrigeration cars; a standard method of splicing A. R. A. center sills. The report pointed out that the greater loads now carried in cars have materially increased arch bar failures. A reduction in maintenance costs can be obtained by gradually replacing existing arch bars with those of larger section as proposed by the committee. The committee reported progress on the design of self-clearing hopper cars.

Owing to the fact that approximately 100,000 single plate wheels and 4,000,000 re-inforced flanged cast iron wheels are in service the Wheel Committee in its report discussed these two items in detail. The committee, recognizing the fact that these two types of wheels are not A. R. A. standards decided, in order to facilitate handling in interchange cars equipped with such wheels, to submit to letter ballot for adoption as standard practice a mounting gage and a maximum flange gage for re-inforced flange cast iron wheels. After thorough investigation, the committee refused to recommend as standard practice the grinding of flat spots with portable grinding machines. As has been mentioned in previous reports, Rule 78 covering the condemnation of chipped rim cast iron wheels is not entirely satisfactory since wheels are condemned by inspectors when they are serviceable. The committee has recommended a change in order to clarify this rule.

As a result of the revision of Rule 66 covering the periodical repacking of journal boxes which was approved by the association in 1926 a committee of the Lubrication of Cars and Locomotives was appointed to make an investigation of the general lubrication of railway equipment. In submitting its first report to the division, the committee discussed the problem of the saturation of waste. In discussing the reclamation of

packing the committee pointed out that this work should be done at a central point. The report also described and discussed the three methods used to reclaim oil. The committee recommended three changes in the application of packing to the boxes.

The report on Couplers and Draft Gears covers the progress that has been made in the installation of a drop test machine at Purdue University for making a series of tests on draft gears.

G. E. Smart, chief of car equipment, Canadian National, and Victor Willoughby, general mechanical engineer, American Car & Foundry Company, each read a paper on the subject of passenger and freight car design and construction in which both agreed that the excessive dead weight of cars should be materially reduced. They pointed out what has already been done to attain this end. Mr. Willoughby discussed at some length refrigerator and container cars, while Mr. Smart discussed corrosion and the application of roller bearings to passenger cars. He also suggested that one method of reducing the excessive dead weight of sleeping cars would be to eliminate upper berths.

Report of committee on car construction

W. F. Kiesel, Jr.
Chairman

Following the practice of recent years, your committee on Car Construction has delegated the various assignments given them to subcommittees, whose reports follow.

Trucks

In last year's report of progress the program of tests was stated in detail, and the loadings of the Symington and American Steel Foundries machines tabulated.

It may be pertinent at this time to call attention to some important differences in method of loading on the two machines, and, for ready reference, these loads, which were given in detail in the report of progress made last year, are repeated herewith:

40-ton frames

Symington Machine	American Steel Foundries Machine
Vertical Load:	Vertical Load:
Maximum, 75,000 lb.	Maximum, 78,000 lb.
Minimum, 30,000 lb.	Minimum, none.
60 applications per minute.	50 applications per minute.
Transverse Load:	Transverse Load:
9,000 lbs. in and out.	10,500 lb. in and out.
12 applications per minute.	100 applications per minute.
6 in each direction.	50 in each direction.
*Center Twist Load:	*Center Twist Load:
6,000 lbs. right and left.	7,000 lb. right and left.
2 applications per minute.	50 applications per minute.
One in each direction.	25 in each direction.
Length of lever arm 38½ in.	Length of lever arm, 58½ in.

50-ton frames

Vertical Load:	Vertical Load:
Maximum, 100,000 lb.	Maximum, 100,000 lb.
Minimum, 40,000 lb.	Minimum, none.
60 applications per minute.	50 applications per minute.
Transverse Load:	Transverse Load:
12,000 lb. in and out.	13,000 lb. in and out.
12 applications per minute.	100 applications per minute.
6 in each direction.	50 in each direction.
*Center Twist Load:	†Center Twist Load:
8,000 lb. right and left.	8,500 lb. right and left.
2 applications per minute.	50 applications per minute.
One in each direction.	25 in each direction.
Length of lever arm, 38½ in.	Length of lever arm, 58½ in.

The following loads are the same for all frames:

End Twist:	None.
1 in. throw of crank.	
12 end twist per minute.	
6 in each direction.	
Center Impacts:	None.
2,090 lb. weight 6¼ in. fall.	
12 impacts per minute.	
6 right and left.	
End Impacts:	None.
12 impacts per minute.	
6 right and left.	

(*) The center twist load applied either to spring plank or bolster guide of the frame.
(†) The center twist load applied only to spring plank.

Vertical load

The American Steel Foundries machine alternates between no load and maximum load, while in the Symington machine the minimum load is never less than 40 per cent, of the maximum. The number of applications per minute does not materially differ in the two machines.

Transverse load

The difference in actual load is not great, but the American Steel Foundries machine applied the load 50 times per minute in each direction, while the Symington machine makes only six applications in each direction per minute.

Center twist load

There is not much difference in the intensity of load, but, in the American Steel Foundries machine, the load is applied 25 times per minute in each direction, with a lever arm 58½ in., while in the Symington machine the lever arm is only 38½ in., with one application per minute, in each direction.

These comments cover both the 40-ton and 50-ton tests.

End twist

The end twist load is obtained by rocking the stub axles on which the frame is supported in each direction, thereby inducing end twist forces.

Center impact

The weight of 2,090 lb., falling 6¼ in., is allowed to strike 12 times per minute, in addition to the normal vertical load, and this center impact is timed to strike at the instant of maximum stress with all the other loads.

The various loads on both machines were applied either through calibrated springs or through accurately measured weights. The proper sequence of loading was determined by various systems of cams and levers.

Both machines were developed for the purpose of greatly exaggerating service conditions, in order to develop in a short time by tests failures that might require years to develop in service. There is no way of determining the exact comparison between the stresses in the machine and stresses developed in actual service, but it is a fact that frames may be tested to destruction in a few days on either one of these machines, that will give satisfactory service over a period of years without failure.

Scope of tests

The tests comprised the following:
Fatigue tests on Symington side frame testing machine.

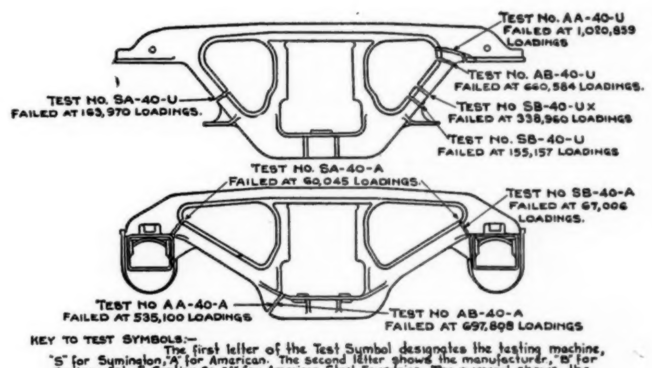


Fig. 1.—Test of 40-ton U. S. R. A. and A. R. A. type frames on Symington and American fatigue testing machines

Fatigue tests on American Steel Foundries side frame testing machine.

Static tests on Baltimore & Ohio tension testing machine of 600,000 lb. capacity.

Tension tests from coupons attached to frames, turned to standard 0.505 by 2.00 in. size, were made at Baltimore & Ohio test bureau.

Chemical analyses from tension test coupons were made at Baltimore and Ohio test bureau.

Photomicrographs of annealing coupons attached to frames were made at Baltimore and Ohio test bureau.

One frame of each type and capacity, furnished by each of the two manufacturers, was tested on the Symington side frame

testing machines. Corresponding frames were tested on the American Steel Foundries machine and on the B. & O. tension testing machine. In addition two U. S. R. A., type frames, one 40-ton and one 50-tons capacity, manufactured by the Buckeye Steel Castings Company, were tested on the Symington machine, with the twist load applied to the spring plank.

Preliminary to tests

Each frame was given a test symbol and marked so that the identity would not be lost. The following examples will indicate the method of marking the test frames.

Test Symbol	Testing machine	Manufacturer	Capacity Tons	Type
SB-50-U	Symington	Buckeye	50	U.S.R.A.
AA-40-A	Amer. Steel Foundries	Am. Steel Foundries	40	A.R.A.
MB-50-A	Baltimore & Ohio	Buckeye	50	A.R.A.

Observations and tests

The height of all springs used for applying the various loads were checked at regular intervals during the tests, in order that all frames might be subjected to the same intensity of stresses. After the tests were started, the machine was run as continuously as possible until failure occurred. The frames were closely observed while under test and notes made regarding cracks, indications of stress, etc. The corresponding number of loads was also noted.

The loads employed in the various testing machines were the same as customarily used by the Symington Company and American Steel Foundries for testing frames of similar capacity. Strain gage readings, to determine the stresses in the various members of the frames, were taken only on the frames tested on the American Steel Foundries machines.

The U. S. R. A. frames were fitted with tie bars and journal boxes for all tests. The box bolts were kept tight throughout the progress of the tests.

After failure, the frames were examined and notes made regarding the extent and location of cracks, as well as the condition of the metal where failure occurred. The tested frames are being held for disposition.

Results of tests

A complete report of the data secured in all these tests has been presented by the subcommittee to the Committee on Car Construction. This report is so voluminous, however, that it is not incorporated completely in this progress report. The results of the tension tests, the chemical analyses, the fatigue tests, and static tests, are also given. In addition, diagrams are included which show the location of the final failure on each of the

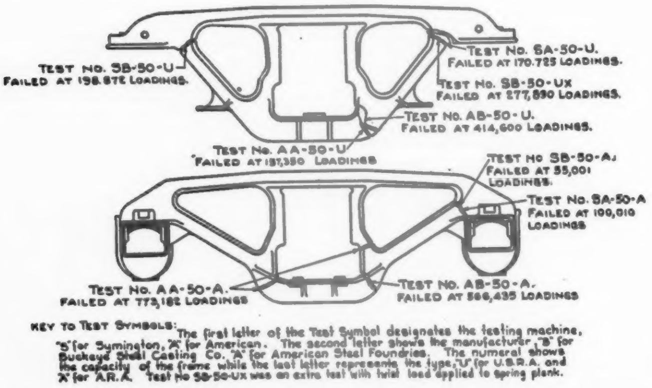


Fig. 2.—Test of 50-ton U. S. R. A. and A. R. A. type-frames on Symington and American fatigue testing machines

frames tested in the American Steel Foundries and Symington machines, together with the number of the machine cycles at which each frame failed.

Summary

The foregoing data and diagram show a rather wide variation in the results of the fatigue tests, but results of the static tests are quite uniform. There are several hundred thousand frames of each design now running, which have been in service several years, with few failures reported, which indicate that, so far as strength is concerned, both designs are satisfactory for general service. In fact, the committee has knowledge of only one failure of the A. R. A. design.

At the junction of the tension and compression members, where the strength of the frame is most severely tested on the Symington machine, the A. R. A. frame failed sooner than the U. S. R. A. type, which the subcommittee feels is due, at least in part, to the support received from the strap on the U. S. R. A. frame, and the fact that the box bolts were kept tight during the tests, which condition might not always obtain in service. The committee feels, however, that the A. R. A. design can be materially strengthened at this point without any appreciable increase in weight and cost, and will undertake to develop this during the coming year.

The tests also developed certain inequalities in strength at different parts of the U. S. R. A. frame, but as this design employs separable journal boxes with box bolts, while the

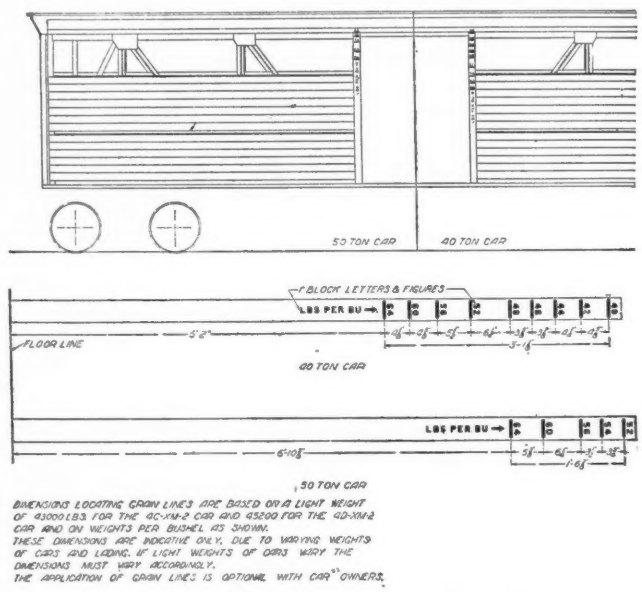


Fig. 3.—Proposed uniform stenciling of grain lines in box cars

standard of the association is the integral box type, the committee will confine its future study to the latter type.

The report of the subcommittee on Trucks is signed by J. J. Tatum (chairman), John Purcell and A. R. Ayers.

Standard car design

Width of underframe of single-sheathed and double-sheathed type cars

The committee on car construction passed a resolution to increase the width of underframe of single- and double-sheathed cars from 8 ft.-9 in. to 8 ft.-9⅜ in., for the purpose of eliminating shims in the construction of double-sheathed cars. This is a minor change, but requires a revision of the drawings. It will not affect the serviceability of the car in any way, and will have little effect on interchangeability; neither will it increase the cost.

In the case of the double-sheathed box car, this change will eliminate the shims shown on Plates 136, 138 and 140 in the Supplement to the Manual. This represents 16¾ lb. of steel per car. There also will be a reduction in the weight of certain parts, such as door post and post connections, etc., shown on Plates 125, 126, 135, 137, 139, 141, 142, 144 and 174, as well as a slight saving in length of certain bolts, all amounting to 15¼ lb., to which should be added a saving of 6¾ lb. of lumber in the side sill nailing strips.

Increasing the width of underframe ⅜-in. over-all will add a corresponding length of material to the cross-members shown on Plates 199 to 205, inclusive, and Plate 207. This addition amounts to 8¾ lb. per car. Summarizing the above, we have

Reduction of metal	32 lb.
Addition of metal	8¾ lb.
Net reduction of metal	23¼ lb
Reduction of wood	6¾ lb.
Total net reduction in weight	30 lb.

Labor costs will not be affected, except in case of the items eliminated, shown on Plates 136, 138 and 140, as it will not be necessary to cut and punch these fillers.

Widening the underframe of the single-sheathed car, with post end construction, will result in an increase in weight of the parts affected, similar to the increase noted above, which is

8¾ lb., from which may be deducted the saving in weight of door posts, amounting to 5¾ lb., giving us a net addition of 3 lb. A further reduction of 1¾ lb. is caused by modification of door guide castings, and, inasmuch as the end lining and flooring will be ⅜ in. longer, the increase in the weight of wood will amount to 10 lb. Summarizing, we have:

Increase in weight of underframe	8¾ lb.
Reduction, door posts	5¾ lb.
Net addition of steel	3 lb.
Reduction, door guide castings	1¾ lb.
Total addition of metal	1¼ lb.
Addition of lumber	10 lb.
Total net addition in weight	11¼ lb.

The inside width of car will be 8 ft.-6⅜ in., instead of 8 ft.-6 in., or an increase of 10¾ cu. ft.

In the case of the single-sheathed car, having a flat plate, or a pressed plate end modifications to the corner posts will result in a saving of 30¾ lb. per car. Other factors considered under the post end construction not being altered, the result is a total reduction in weight of car of 19½ lb.

It will be noted from the above that the proposed widening of underframe does not penalize the construction relative to weight and cost, but does improve the design of double-sheathed house cars without handicapping the single-sheathed types in any way.

The report of the subcommittee on Underframes is signed by J. T. St. Clair.

Stenciling grain lines in box cars

A member suggested that a uniform practice for stenciling grain lines in box cars used for grain loading be established. Communications from various roads indicates that some use grain lines marked for oats, corn, wheat, etc., to which such grains may be loaded. One uses a method which shows grain lines marked "pounds per bushel" to which grains having corresponding weights per bushel may be loaded. Some roads do not use grain lines, since grain is weighed at the elevators on these roads before it is loaded.

Grains of the same kind vary considerably in weight. For example, corn varies from 38.5 lb. to 56 lb., per bushel; oats from 32 lb. to 38.5 lb.; wheat from 48.5 lb. to 62 lb.; so that it was decided that the most satisfactory method for stenciling grain lines is the method which shows grain lines marked "pounds per bushel," and drawing showing this method is, therefore, submitted, with the recommendation that, if a standard practice be established, this method be adopted.

Open-top cars are loaded with various commodities, such as coal, sand, gravel, iron ore, etc., and no provisions are made for limiting the amount of such commodities loaded, except the load limit marking on the car, and it is, therefore, felt that the loading of grain in box cars should be governed by the same requirements, and that stenciling of grain lines in cars is not universally necessary, although it may be required by some local conditions, on certain roads. Furthermore, grain lines in cars are of no value unless the grain load is leveled-off or trimmed. (See drawing.)

The report of the subcommittee on Stenciling Grain Lines is signed by A. R. Ayers.

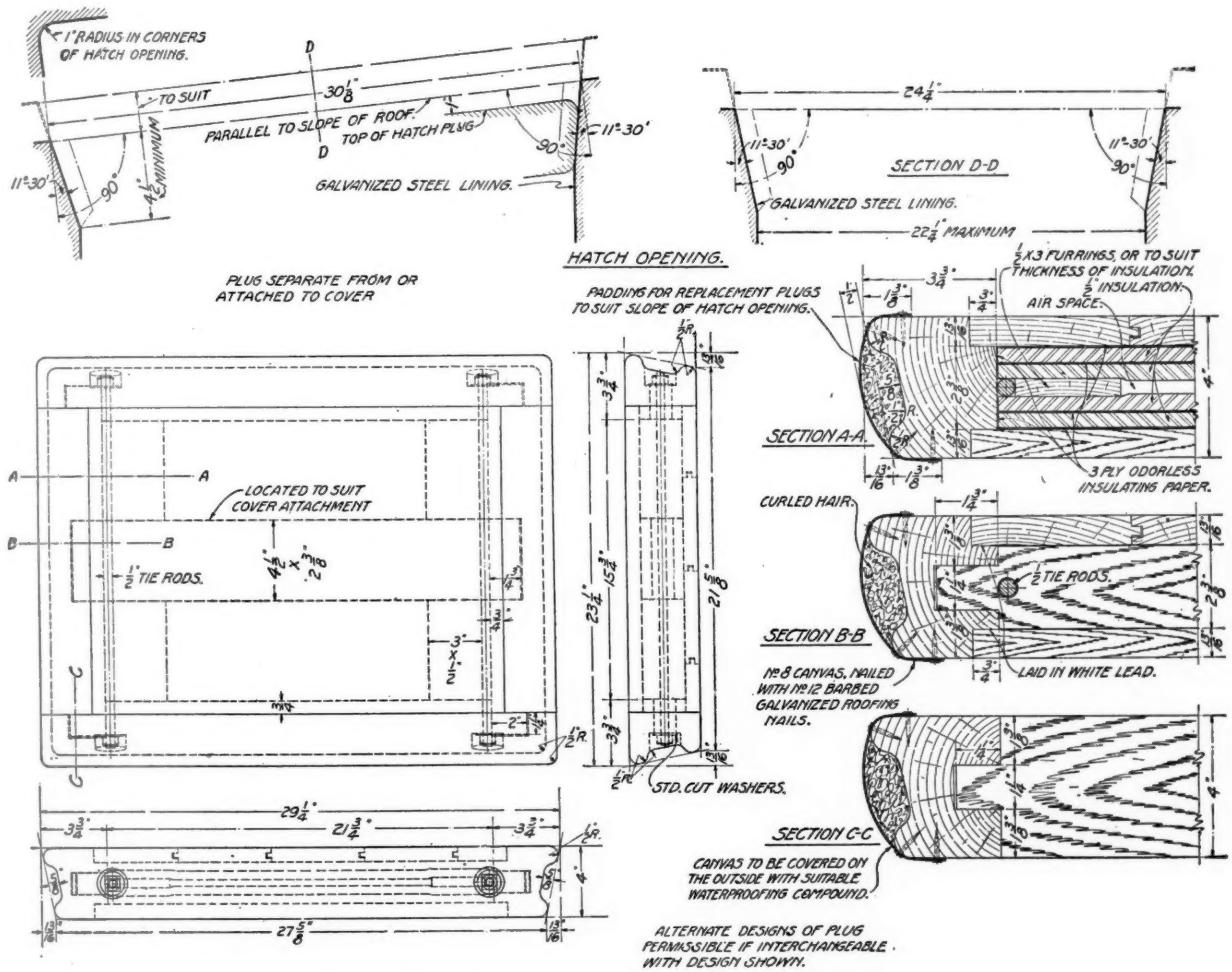


Fig. 4.—Modified design of hatch plugs for refrigerator cars

Designating letters for car equipment

Attention was directed to the advisability of changing the designating letters "TS" to evade possible confusion, and eliminating the designation "FT." A study of this subject indicates the criticism is just, hence we recommend the following for adoption:

"TMU"—A car equipped with holders, other than glass lined for the transportation of gas and liquids. (In place of "TS.")

"TW"—A car equipped for the transportation of pickles in brine.

"RT"—Refrigerator cars for transporting milk in bulk.

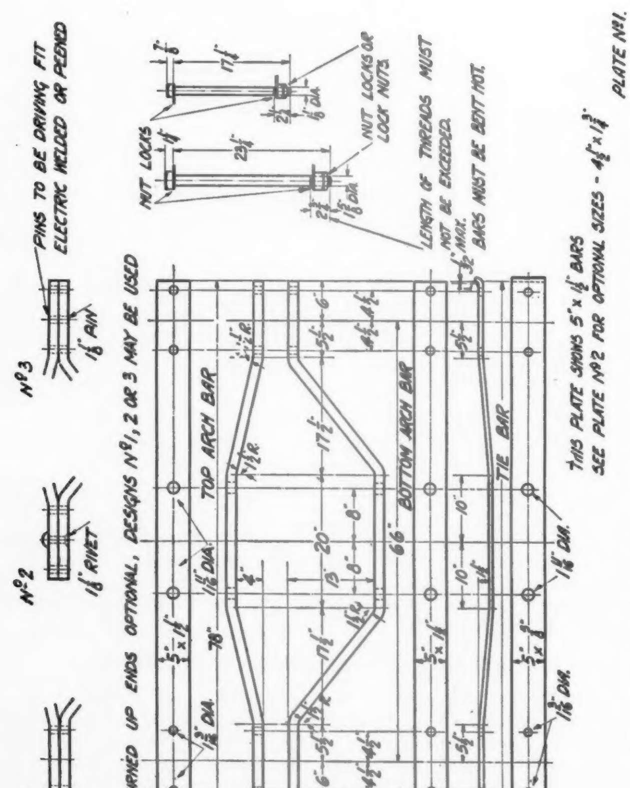


Fig. 7—Plate 1, 5 in. by 1½ in. arch bars for 40-ton trucks

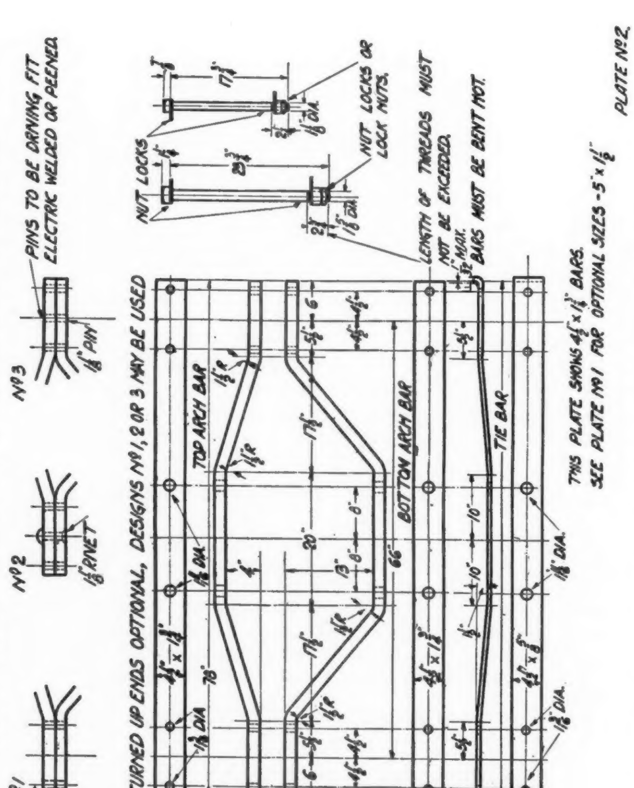


Fig. 8—Plate 2, 4½ in. by 1¾ in. arch bars for 40-ton trucks

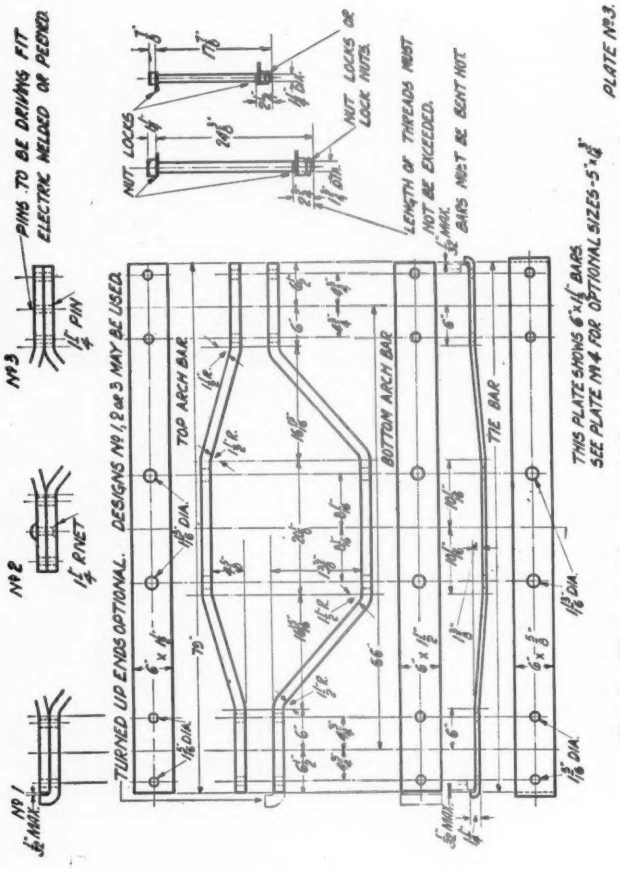


Fig. 9—Plate 3, 6 in. by 1½ in. arch bars for 50-ton trucks

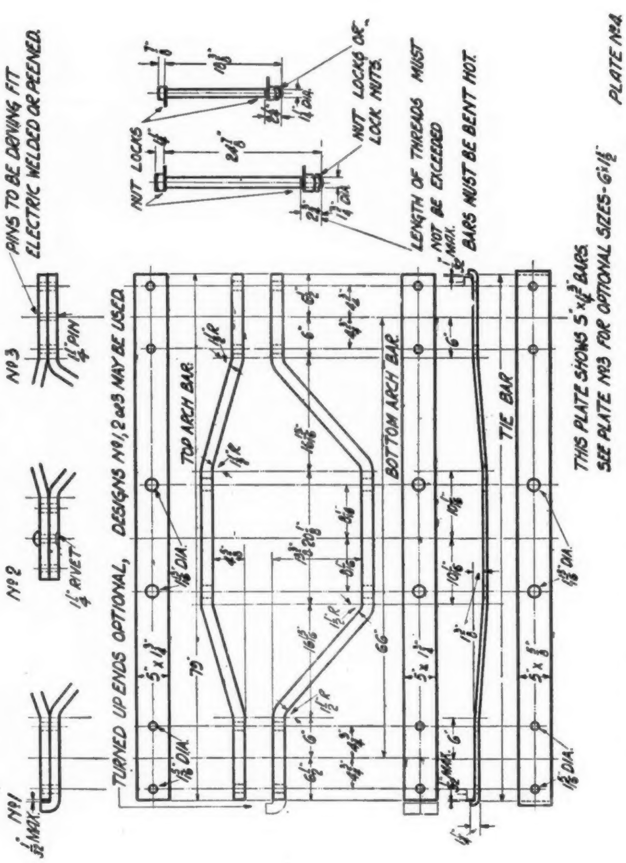


Fig. 10—Plate 4, 5 in. by 1¾ in. arch bars for 50-ton trucks

The report of the subcommittee is signed by J. McMullen (chairman) and Ira Everett.

Box car ends

In compliance with instructions, we have revised recommended practice specification covering box car ends, shown on pages 7 and 8, Sec. C, of the Manual, and submit the following statement showing present specification, proposed specification, and the more important data used in connection with this revision:

Ends for both new and existing cars have been covered, and the adoption of the proposed requirements will involve no change in ends which have been applied to A. R. A. Recommended Practice house cars.

Although this specification relates specifically to corrugated, reinforced, flat plate, and pressed steel ends of various designs, and in our opinion, it is not practicable to construct a composite end having strength equivalent to the types enumerated, specification for a composite end has been included as an alternate arrangement. Insofar as practicable, the use of this end should be confined to stock cars.

It is our recommendation that the Comparative Statement Showing Present and Proposed Specifications Covering Design and Strength of Steel Ends for House Cars, a portion of which is intended to supersede the specifications now contained in the Manual, be submitted to the members of the Mechanical Division of the Association, in order to provide full information on the proposed specification for use in connection with letter ballot vote.

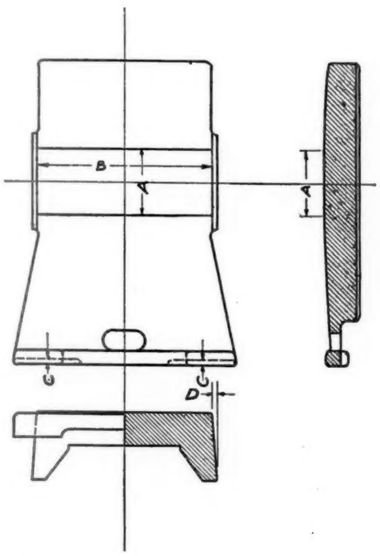


Fig. 5—Exhibit No. 2, wear of journal wedges

Present and proposed A. R. A. specifications covering design and strength of steel ends for house cars

Paragraphs are numbered in the order in which they appear in the A. R. A. Manual.

PARAGRAPH 1

Present—(1) News cars should have corrugated steel ends or steel plate ends $\frac{1}{4}$ in. thick, reinforced between corner posts with the equivalent of either two vertical steel braces with a total section modulus of not less than 9; or one vertical and two diagonal steel braces with a total section modulus of not less than 10; or three horizontal steel braces with a total section modulus of not less than 10.

Proposed—(a) Ends for new cars other than refrigerator cars shall be of steel, of either corrugated, pressed plate or reinforced flat plate construction and may be made of one or more pieces. When one piece is used it must be not less than $\frac{1}{4}$ in. in nominal thickness. When constructed of more than one piece, the lower third of the end must be made in one piece and not less than $\frac{1}{4}$ in. in nominal thickness and the remainder shall not be less than $\frac{3}{16}$ in. in nominal thickness.

PARAGRAPH 6

Present—(6) The corrugated ends referred to may be made of one or more pieces. If made of one piece, it should not be less than $\frac{1}{4}$ in. thick. If made of more than one piece the lower third must not be less than $\frac{1}{4}$ in. thick, and the remainder should not be less than $\frac{3}{16}$ in thick.

Proposed—(b) Flat plate ends shall be reinforced with not less than three steel braces having a total minimum section modulus, when figured independently of end sheet, of not less than 8.4 in.^{3}. When more than three braces are used they must have an individual section modulus of not less than 2.5 in.^{3}. Section modulus may be calculated without deducting rivet holes. When vertical braces are used, they must be symmetrically located about center of end and the distance between their centers must be not greater than 0.2 of inside width of car.

When horizontal braces are used, they must be so located that the distances between their centers, and the distance from top of floor to the center of the bottom brace are not greater than 0.2 of the clear inside height of car.

Remarks—The three present A. R. A. end post sections have a least modulus of 8.40 in.^{3}

The A. R. A. 50-ton Double and Single Sheathed cars have end posts located on 18 in. centers. By use of the factor of "0.2 of the inside width," the maximum distance between end posts for these cars would be:

D/S Car = 103.75 in. x 0.2 = 20.75 in.
S/S Car = 102 in. x 0.2 = 20.40 in.

The A. R. A. 50-ton Double and Single Sheathed cars, when equipped with all-steel roofs, have clear inside height of 8 ft. 7$\frac{1}{4}$ in.

By use of the factor "0.2 of the clear inside height," the maximum distance between braces and between the bottom brace and the top of the floor would be:

103.25 in. x 0.2 = 20.65 in.

Proposed—(c) Corrugated ends shall have a total minimum section modulus of not less than 1.45 times the clear inside height of car in feet. Pressed steel ends, other than those commonly termed as corrugated, shall have minimum strength requirements equivalent to those specified for corrugated ends.

Remarks—The total minimum section modulus for a corrugated end in general use on a car having an inside height of 8 ft. 7 in. equals 12.85 in.^{3}

12.85 ÷ 8.58 = 1.50.

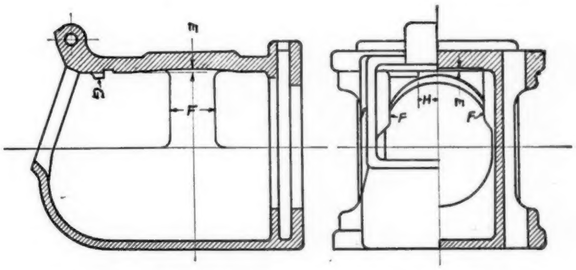


Fig. 6—Exhibit No. 3, wear of journal boxes

Section modulus for one foot (2 corrugations) of corrugated end in general use:

$\frac{1}{4}$ in plate = 1.74 in.^{3}
$\frac{3}{16}$ in. plate = 1.42 in.^{3}

Clear inside height A. R. A. box cars:

S/S Box Car, Steel Roof 8 ft. 7$\frac{1}{4}$ in.
D/S Steel Frame Box Car, Steel Roof 8 ft. 7$\frac{1}{4}$ in.
D/S Steel Frame Box Car, O. M. Roof 8 ft. 5$\frac{7}{8}$ in.
D/S Auto Box Steel Roof 9 ft. 3 in.

PARAGRAPH 5

Present—(5) Lining at car ends should be supported at intervals not greater than 30 times the thickness.

Proposed—(d) The unsupported distance between lining supports at car ends shall be not greater than 20 times the lining thickness.

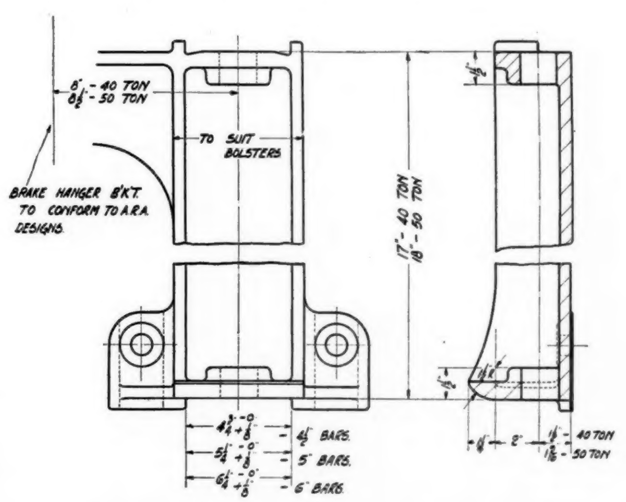


Fig. 11—Column casting for arch bar trucks

Remarks—Proposed maximum spacing of lining supports is based on present A. R. A. flat plate ends.

PARAGRAPH 2

Present—(2) New cars may have the following alternative arrangement: Three or more steel braces, two of which run diagonally, with a total section modulus of not less than 12½, and wood lining 1¾ in. thick.

Proposed—(e) Stock cars may have the following alternative arrangement:

Not less than four steel braces, two of which run diagonally, having a total minimum section modulus of 12.0 in.^{3} Section modulus may be calculated without deductions for rivet or bolt holes.

Remarks—While it is not felt that the specified composite end is equivalent in strength to an all steel end, it has been included in the specification in order to provide an end suitable for application to stock cars.

PARAGRAPH 3

Present—(3) To concentrate strength at a point near floor line on vertical center line of car, diagonal braces should extend from the center sills to the side plates, and not from the bottom corner to the ridge.

Proposed—Wood sheathing must be not less than 1¾ in. thick. The vertical braces shall be symmetrically located about center of end and the distance between their centers must be not greater than 0.27 of the inside

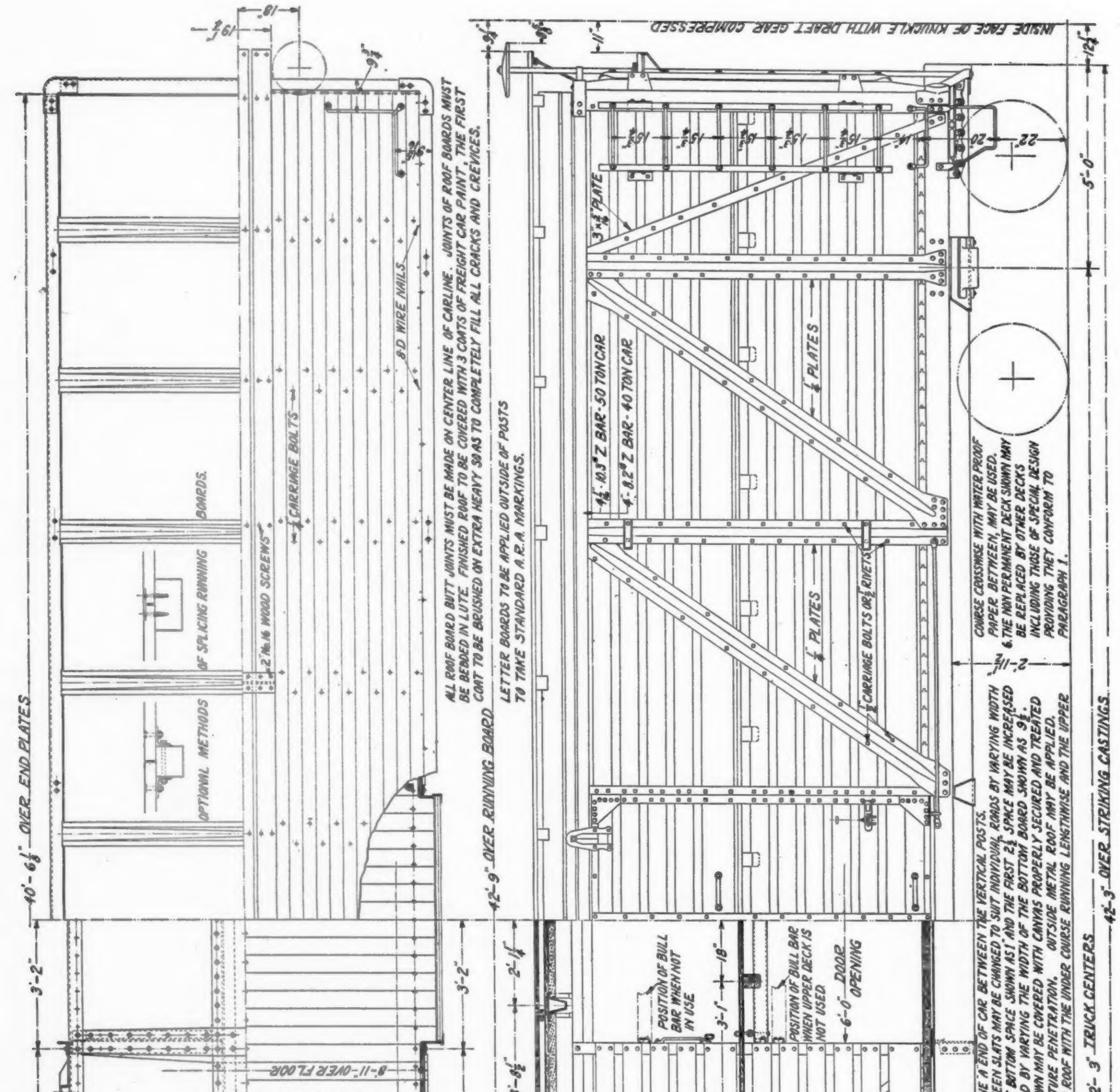


Fig. 12—Proposed standard 40-ton and 50-ton stock cars

width of car. The diagonal braces must extend from the bottom of the vertical braces to the intersection of end plate and corner post.

Remarks—The four present A. R. A. end post and brace sections have a least section modulus of 12.1 in.^{3}

The A. R. A. 50-ton Single Sheathed car has two end posts located 27 in. center to center. By use of the factor "0.27 of the inside width of car," the maximum distance between centers of vertical braces for this car and for the proposed A. R. A. stock car would be:

S/S Car = 102.27 x .27 = 27.5 in.
Stock Car = 102.5 x .27 = 27.7 in.

Paragraph 4

Present—(4) The attachments for the braces and the members to which they are attached must be sufficiently strong to realize the full strength of the braces.

Proposed—(f) The connections for end braces and the members to which

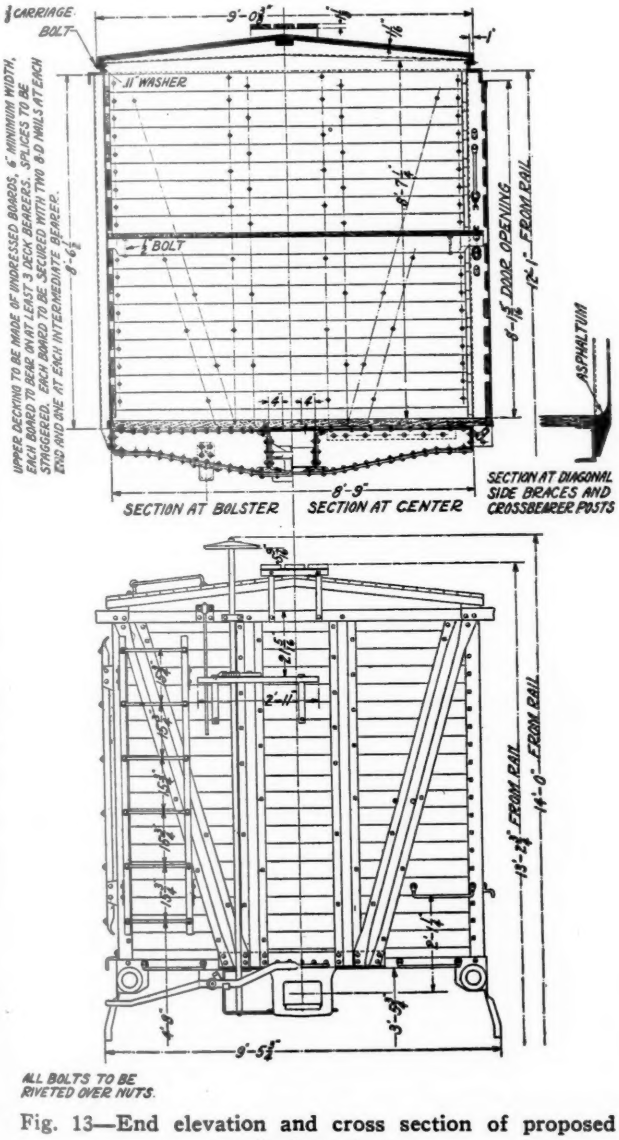


Fig. 13—End elevation and cross section of proposed standard stock cars

they are attached must be sufficiently strong to realize the full strength of the braces.

(g) The attachment of the end to the car structure should be consistent with the strength of the various parts involved.

Paragraph 7

Present—(7) On house cars (other than refrigerator cars) with steel underframes or steel center sills, having a center sill area of not less than 24 sq. in., when an end requires repairs consisting of new posts and braces, the ends shall be replaced with ends specified for new cars, this to be done by or under the direction of the car owner.

Proposed—(h) Ends on house cars (other than refrigerator cars) with steel underframes or steel center sills, having a center sill area of not less than 24 sq. in., that require repairs consisting of new posts and braces, should be replaced with ends equivalent in strength to those specified for new cars. This work to be done by or under the direction of the car owner.

The report of the subcommittee on Box Car Ends is signed by W. O. Moody (chairman), W. A. Newman, P. W. Kiefer.

Hatch openings for refrigerator cars

Letter ballot circular dated September 10, 1925, was submitted and approved. This letter ballot, under item 4, approved, as recommended practice, a design of hatch plug and slope of hatch opening for refrigerator cars as shown in Fig. 1 accompanying the letter ballot.

Complying with the request of a number of private refrigerator line companies, your committee has since reviewed this design, and recommends that the drawing be changed to embody a number of features that will make the design more acceptable to those interested. This design is shown on accompanying drawing, and, for ready reference, the following features are referred to:

Hatch opening

1—The slope on all four sides has been made uniform and shown as 11° 30'.
2—A filet of 1 in. radius has been placed in each corner of opening.
3—The minimum depth of slope has been changed from 4¼ in. to 4½ in.
4—An outline of plug in position has been indicated.
5—Extension of sloping sides of hatch opening has been shown so as not to restrict designs of hatch frame.
6—Note reading: "Slope of roof 1⅜ in. in 12 in.," has been removed.
7—Note has been added reading: "Plug separate from or attached to cover."

Hatch plug

1—Note has been added reading: "Alternate designs of plug permissible, if interchangeable with design shown."
2—Corners of framing show a ½ in. radius.
3—Plug was made 4 in. deep allowing for additional ½ in. of insulation.
4—Contour of framing has been modified to take the hair packing.

The changes indicated above tend to improve the design and render it the more acceptable for general use. It is therefore, recommended by your committee that the design adopted as Recommended Practice be modified to incorporate the changes shown in the drawing accompanying this report.

The report of the subcommittee on Hatch Openings is signed by John Purcell.

Automobile cars

Preliminary designs of unrestricted as well as restricted 40- and 50-ton double-sheathed automobile cars have been developed. As referred to in the 1926 report, letter ballot was submitted to develop if 40- and 50-ton, unrestricted or restricted, cars are desirable, together with different side door openings, also whether the restricted car should be of the 40-ft.-6-in. or 50-ft.-6 in. inside length.

Result of letter ballot was very inconclusive, and a special committee was appointed to visit a large number of automobile manufacturing plants, in conjunction with the National Automobile Chamber of Commerce, and, as soon as necessary data is compiled, the sub-committee will then be in position to further analyze this matter, in order that a supplementary letter ballot may be prepared on more definite propositions. After result of letter ballot is known, design will be made accordingly for final submittal.

The report of the subcommittee on Automobile Cars is signed by O. S. Jackson (chairman), and John Purcell.

Method of attaching brake beam hangers to side frames

At the 1926 annual meeting, the subcommittee's report on the above subject was submitted and all recommendations were later presented to letter ballot vote, and were finally adopted as recommended practice, effective March 1, 1927.

As instructed, the subcommittee referred the general design of the bracket to George G. Floyd, chairman of the Manufacturer's Truck Committee, as a result of which slight refinements were made in the design of the bracket, to accommodate standard foundry practices. As further requested, the width of slots for the brake hanger, on each side of the center bearing of the bracket, was increased from 1⅛ in. to 1 3/16 in., without changing the length of the center bearing, in order to accommodate Schaefer loop hangers.

The report of the subcommittee on Method of Attaching Brake Beam Hangers is signed by A. H. Fetters (chairman), Ira Everett, and K. F. Nystrom.

Journal wedges, and limiting gage

Your subcommittee has inspected nearly 2,000 journal boxes and journal wedges, and endeavored to select cars which have been in service from 10 to 20 years in order to ascertain the maximum wear. The inspection covers the journal boxes and journal wedges from various types of freight and passenger car trucks most commonly used at present.

Your committee finds that the wear on top of the wedge, in form of a flat spot, dimension *A*, Exhibit 2, varies from zero to, in isolated cases, 6 in. The wear on the sides of the wedges, dimension *B*, Exhibit 2, is negligible, but end wear is common. The end wear of the journal wedge takes place at the front, indicated by dotted lines, *C*, Exhibit 2, where it comes in contact with the two lugs projecting from the roof of the journal

box. This wear, between the front end of the journal wedge and the lugs on the roof of the journal box, contributes considerably to excessive lateral clearance, causing the inner face of the journal box to wear against the hub of the wheel.

As stated, the wear on the sides of the journal wedge is negligible, but some dropped-forged wedges are made with tapered sides. This is objectionable, particularly if the wedge is wider at the top than at the bottom, as it has a tendency to tilt when brakes are suddenly applied. Your committee recommends a limiting dimension, *D*, for the slope of the wedges.

The wear of journal boxes, from the wedge at top, dimension

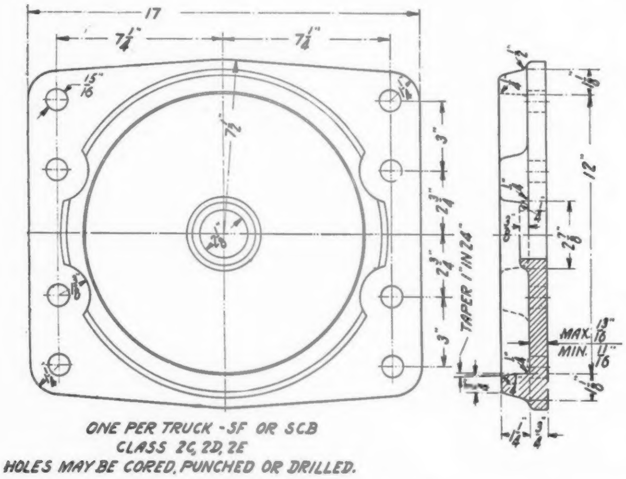


Fig. 15—Proposed truck center plate for separable center plate bolster

E, and on the sides at *F*, was not appreciable. A slight wear was noticeable on the sides of the box at *F*, from the journal brass, but not sufficient to justify placing a limit for wear at this point. The lugs in the roof of the box, marked *G*, do not provide sufficient bearing area for the end of the wedge, and, therefore, it is recommended that the length of these lugs be increased by reducing dimension *H*.

In view of the above, your committee recommends to condemn wedges as unfit for further service, when the following limits are reached:

(a) When the length of the flat spot on the top of the journal wedge exceeds the nominal diameter of the journal. Example: Wedges for 5 in. by 9 in. journal will be condemned when the flat spot exceeds 5 in. in length.

(b) Wedges to be condemned when the length over-all, measured at the contact surfaces, is more than $\frac{3}{16}$ in. below the nominal length. This may be restored by welding.

The following changes in the journal box wedge are recommended:

(1) Width at the bottom of new wedges to conform with present standard. The width of the wedges at the top may be $\frac{1}{16}$ in less over-all than at the bottom.

(2) The length of lugs in the roof of the journal boxes to be increased on each side to within ¼ in. of the center of the box.

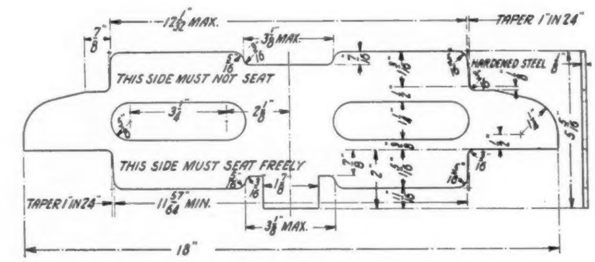


Fig. 16—Proposed truck center plate gage

(3) Correct Manual to show all guides inside of journal box with a flat surface in place of cored-out surface.

Attached hereto is exhibit No. 1, showing the contour of the top of wedge and the amount of wear for a given length of flat spot. Exhibits Nos. 2 and 3 show journal wedge and journal box, respectively, with dimensions used.

The report of the subcommittee on Journal Wedges is signed by Ira Everett (chairman), J. McMullen, R. H. Dyer, and K. F. Nystrom.

Standard blocking for cradles of car dumping machines

Your subcommittee was requested to make a study of the standard blocking provided for car dumping machines, to establish what changes, if any, were necessary to better arrange

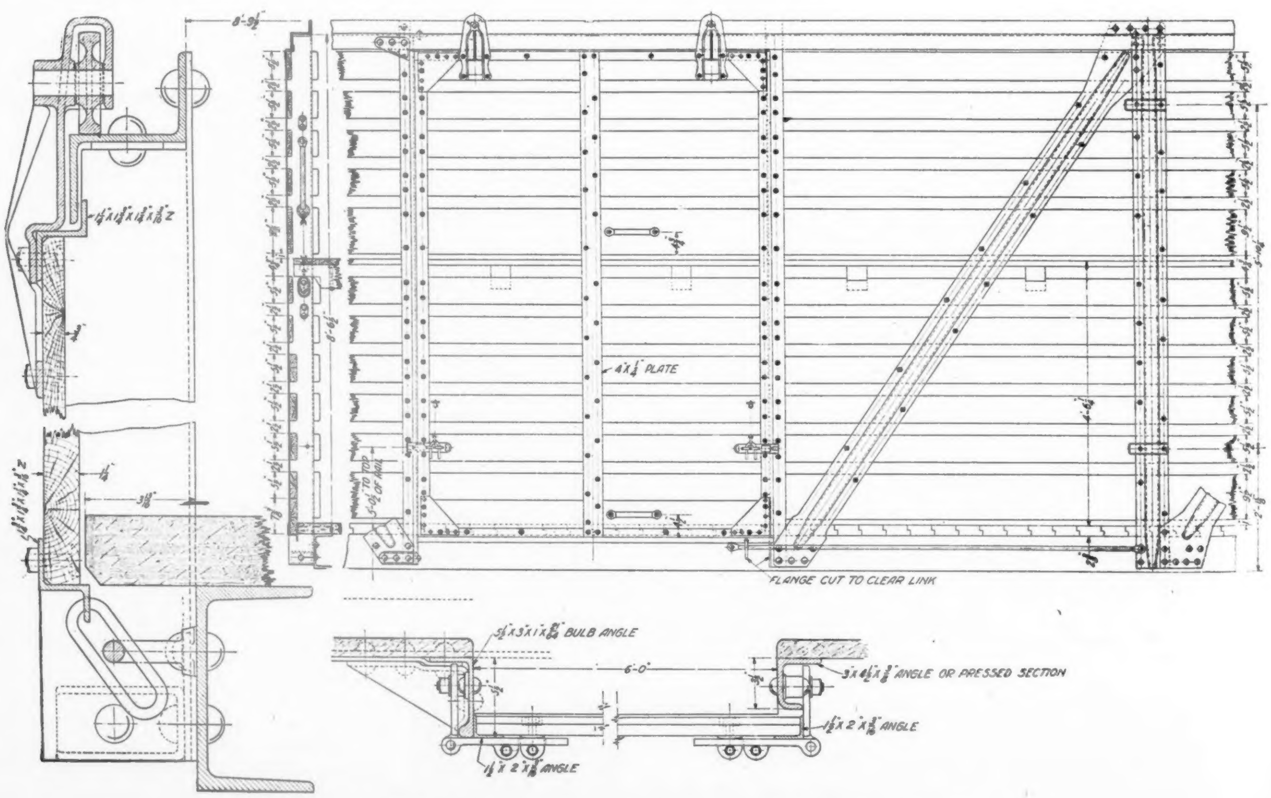


Fig. 14—Side door arrangement for proposed standard stock cars

them, so the blocking would insure better protection to the cars, against damage, which are required to be unloaded on these machines.

The committee has not had sufficient time to go into the matter as thoroughly as it expects to. It has, however, obtained drawings from various roads, showing the method of blocking made use of. The information develops that the existing standard blocking provided for these machines is about as satisfactory as can be provided for the reason that it is seldom that machines are built exactly alike. Also it is rarely, if ever, that all the same build of cars are used on any one machine. For this reason, the blocking is found to vary on each machine, so as to suit local conditions.

To establish a standard that can be used on all machines and under all conditions—at least for the time being—appears to be impossible. Such an arrangement may be possible if all machines could be built of one design, and all cars in service were alike. Necessarily, for the want of time to go into the matter further, and to make more definite recommendations, this report can only be considered a progress report.

(A drawing, not shown, of the present standard blocking accompanied the report.)

The report of the subcommittee on Blocking for Car Dumping Machines is signed by J. J. Tatum (chairman), J. A. Pilcher, and J. McMullen.

Design of refrigerator cars

Your subcommittee was instructed to prepare drawings covering a steel-framed refrigerator car, with A. R. A. underframe and trucks. Cross-section of such a refrigerator car, based where possible on box car design and falling within the standard clearance limits, was submitted for criticism. This cross-section indicated a distance between bulkheads of 33 ft.-2⅝ in., together with total inside length of car of 39 ft.-11⅞ in.

The roads represented by members of the subcommittee are now building a number of steel-frame refrigerator cars, closely to the proposed A. R. A. design, which will develop the builders' views in regard to construction features and place the subcommitttee in position to perfect the design during the construction of these cars, and before submitting final detailed drawings.

Your subcommittee feels that a preliminary design with sufficient drawings to show the general construction of the car might be submitted to the Refrigerator Car Owners' Organization, as well as to the members of the committee on Car Construction, and thoroughly criticized and discussed before the detail drawings are prepared.

The report of the subcommittee on Refrigerator Cars is signed by A. H. Fetters (chairman), J. T. St. Clair, and C. H. Harding.

Arch bar trucks

Arch bar truck failures have been sufficiently extensive to warrant the adoption of revised standards for maintenance. The new sections are based, as far as practical, on the stress analysis of the A. R. A. recommended standard cast steel truck frames, excepting that the limitation for combined stress has been set at 20,000 lb. per sq. in.

On account of the diversity of sizes of arch bars now in common use, it is thought advisable to recommend two sizes of strengthened arch bars, one of increased width over the present A. R. A. standard, and one of increased thickness.

It is unanimously recommended that:

1—The dimensions of arch and tie bars to be used for maintenance of existing trucks shall be:

Arch Bars: Either 1¾ in. by 4½ in. or 1½ in. by 5 in. for 40-ton trucks; 1¾ in. by 5 in. or 1½ in. by 6 in. for 50-ton trucks.

Tie Bars: ⅝ in. by 4½ in. or ⅝ in. by 5 in. for 40-ton trucks and ⅝ in. by 5 in. cr ⅝ in. by 6 in. for 50-ton trucks.

2—When, for any cause, it is necessary to renew the bottom or inverted bar of a truck, both inverted bars on that truck should be changed to the recommended standard, such change to be at owner's expense, in accordance with Sec. A, Interchange Rule 17. Should the new A. R. A. inverted arch bars prevent the reapplication of top arch bars and tie straps, then top arch bars and tie straps of new A. R. A. design shall be applied, billing to be in accordance with Sec. A, Interchange Rule 17.

3—Column castings should be of malleable iron or cast steel and conform to the general design and dimensions as covered by Exhibit A.

4—The shear value of arch bar connections above the journal box should be increased by one of the optional methods shown on plates 1, 2, 3 and 4.

5—The shear value of journal box and tie bar connections should be increased by turning up the end of the tie bars, as shown on plates 1, 2, 3 and 4.

6—Journal box and column bolts of the better grade of steel should be considered, and this question should be referred to the Specifications Committee, for advice as to whether an improved specification can be provided that will give a material of greater shear and tensile strength without increasing danger of heads breaking off.

The report of the subcommittee on Arch Bar Trucks is signed by W. A. Newman (chairman), C. B. Smith, and J. McMullen.

Single sheathed box and stock cars

Your subcommittee on Design of Single-Sheathed Box Car was instructed to prepare a design of 40- and 50-ton stock cars, utilizing standard box car details as far as possible. No report, other than to indicate that the designs were under way, was made last year. This design, now presented for approval, is covered by the two cuts attached, one showing the general arrangement of car, the other the arrangement of side door. These drawings represent both the 40- and 50-ton cars; the only difference between the two being in the trucks, and the thickness of top side Z-bar, corresponding with those of the single-sheathed car.

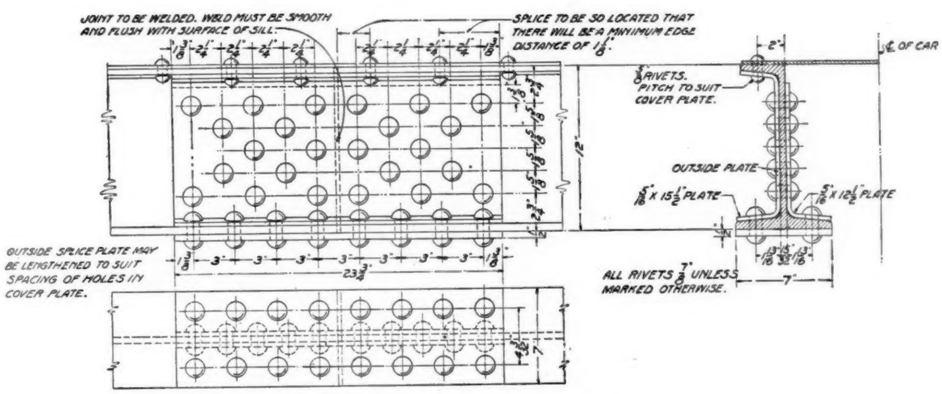


Fig. 17—Proposed standard method of splicing A. R. A. center sills

Details of the single-sheathed box car were utilized as far as possible, and the single-sheathed car underframe, side posts and braces, with necessary modifications in punching of the latter, have been incorporated. The difference in punching and in door posts is due to using slatted sides and stock car type doors.

Safety appliances conform to those of the single-sheathed cars. It should be understood that any modifications approved by the Association for the single-sheathed car will automatically also cover the stock car.

Where legal or railroad requirements compel variations in arrangement, such permissible alternates are covered by notes. Special alternates are covered by notes, but it should be understood that the general rules covered by Plate A of the Specifications for A. R. A. box cars, dated October 7th, 1926, also apply to this car.

These two plans clearly indicate the detail construction, and as soon as we receive your approval thereof, we will proceed with the detail drawings, making the design complete. The classifications will be as follows: 40 Ton Stock Car, Class 4CSl; 50 Ton Stock Car, Class 4DSCl.

The report of the subcommittee on Design of Stock Cars is signed by C. R. Harding, (chairman), and W. F. Kiesel, Jr.

Summary

TRUCKS

The subcommittee points out variations in results of tests on the two machines, due to the different methods of applying

load, which requires further study to determine which corresponds with maximum service conditions.

This progress report, as given, indicates that side frames bought on specifications adopted as Recommended Practice in 1926 give satisfactory service; that the possibility for improvement in the A. R. A. side frame design should be carefully determined, which we will do.

Standard car design

The detail report on width of underframe gives good reasons for increasing this width by 3/8 in., which increases the inside width of single-sheathed cars from 8 ft.-6 in. to 8 ft.-6 3/8 in. This should be submitted to letter ballot for adoption, and, if adopted, the drawings will be changed accordingly.

Lettering and marking

This is mainly a transportation matter, and the subcommittee endeavored to conform to what was indicated to be the best arrangement for uniformity of practice. This item should be submitted to letter ballot.

Designating letters for car equipment

The changes recommended will serve to clarify discrepancies, so that misunderstandings will be reduced. This should be submitted to letter ballot.

Box car ends

This report should be carefully studied. The interest is to make the rules such that there is greater assurance against damaged ends. It should be submitted to letter ballot.

Hatch openings for refrigerator cars

A great amount of work has been expended on this subject. The various interests involved are in agreement. Although this would appear to be a minor feature, the standardization of a design to be used on all cars is of great importance. It should be submitted to letter ballot.

Brake beam hangers and supports

The modification reported may be considered a provision for 1/16 in. greater clearance. It is not an actual change in design; and it is suggested that the change be approved without submitting it to letter ballot.

Design of journal wedges, and limiting gage therefor

The changes recommended are intended to insure more uniformity, and should be submitted to letter ballot. If adopted, the gages shown in Sec. B, page 23, (1926), of the Manual, should be made to conform. The gages shown in Sec. B, pages 17 to 21, inclusive, (1926), which are obsolete, should be eliminated, and gages shown on pages 22 and 23 should be advanced to standard. This should also be referred to letter ballot.

Design of truck center plate

Breakage of the rim of collar around the king pin hole has been reported to be on the increase. Several railroads have reduced the height of this rim to 3/8 in., and changed the contour, to provide necessary clearance under all conditions. This is shown on accompanying diagram, and is submitted for your approval by letter ballot, after which the center plate drawings and gages therefor should be revised. An affirmative vote will carry with it your authority to make the necessary changes in the Manual.

Splice for A. R. A. center sills

To facilitate repairs to standard A. R. A. center sills, the committee presents accompanying drawing of a standard splice, for use at any point between bolsters, one splice, being permitted in each center sill. This should be submitted to letter ballot.

Truck springs

Although there is no report to submit this subject is under investigation in co-operation with manufacturers. Progress has been made and a number of tests are under way. Prospects for an interesting report later are good.

Arch bars

Greater loads now carried in cars have materially increased arch bar failures, hence it will reduce cost of maintenance to gradually replace existing arch bars with those of larger section, as proposed, which are more commensurate with other designs. This should be submitted to letter ballot.

Self-clearing hopper cars

By special Letter Ballot, the height of hopper cars was fixed at 10 ft.-8 in. Since this was definitely fixed, there has not been sufficient time for the subcommittee to make a design subject to the new conditions. They report progress.

Stock cars

Every effort was made to bring this stock car design up-to-date, and to permit special acceptable preferences of the different roads. There is one feature, the length of car, which cannot be compromised. There are advocates for various lengths, from 36 ft.-0 in. up. Investigation discloses the fact that the controlling factor is the spacing of loading chutes, that this spacing varies materially in different localities, and a large number of such chutes are in a condition to require rebuilding anyway. Hence, the more important factor will be to adopt a standard length that can be kept standard for the longest time. This, in the judgment of your committee, justifies using the box car length which permits using the single-sheathed box car framing design for new cars, also permits converting box cars into stock cars and vice versa. It then permits spacing chutes at a standard distance to suit the standard car. This should be submitted to letter ballot.

Lumber for cars

Specifications for lumber have been discussed with and suggestions made to the committee on Specifications and Tests for Materials. Consistent efforts have been made to agree on standard sections that will conserve lumber, be easy to obtain, and that will be suitable for the various requirements for cars. A few minor differences will yet have to be adjusted, after which we can submit report.

Possible patent infringements

The status of patents in connection with A. R. A. car design has been raised frequently. The designs of A. R. A. cars were, therefore, submitted to the Eastern and Western Railroad Associations by member railroads, a voluminous report has been received, and is now being carefully studied. The reports point out many features which, under certain conditions, may infringe existing patents. We have reason to believe that our study of the reports, based on a knowledge of the state of the art, will eliminate a large number if not all of these possibilities of infringement. Where it is believed that an item is not entirely clear of infringement, this will be recorded on the drawing of the detail involved.

The report of the Committee on Car Construction is signed by W. F. Kiesel, Jr., (chairman), Pennsylvania Railroad System; A. R. Ayers, New York, Chicago & St. Louis; O. S. Jackson, Union Pacific; C. L. Meister, Atlantic Coast Line; J. McMullen, Erie; John Purcell, Atchison, Topeka & Santa Fe; W. O. Moody, Illinois Central; J. A. Pilcher, Norfolk & Western; P. W. Kiefer, New York Central; C. B. Smith, Boston & Maine; S. O. Taylor, Missouri Pacific; Ira Everett, Lehigh Valley; W. A. Newman, Canadian Pacific; G. S. Goodwin, Chicago, Rock Island & Pacific; J. J. Tatum, Baltimore & Ohio; L. K. Sillcox, Chicago, Milwaukee & St. Paul; E. B. Dailey, Southern Pacific.

Discussion

On the subject of attaching brake beam hangers to the side frame, A. H. Fetters (U. P.) said that the subcommittee, in an inspection of four or five hundred cars, had found a heterogeneous variety of attachments, and said that here was at last one detail which required some sort of standardization. A major portion of the discussion was devoted to the advisability of the association going on record to increase the size of arch bars, as such an action would put the association's stamp of approval on arch bar trucks. Some of the speakers defended the arch bar trucks from the standpoint that they should be strengthened and kept in service until the cars they are under are scrapped. Others took the position that the failure of arch bar trucks has caused many derailments and, therefore, they should be taken out of service as quickly as possible. This argument was refuted by the statement that proper maintenance will greatly eliminate arch bar failures. A motion was made that the recommendations on arch bars be held in abeyance. After this motion was lost, another motion was made to the effect that the committee be requested to revise the recommendation simply to

cover the renewal of the bar that is found broken on foreign lines. This motion was carried.

With the exception of the sections of the report pertaining to Designating Letters for Car Equipment, Hatch Openings for Refrigerator Cars and Design of Journal Wedges, which were submitted to letter ballot, the committee's report was accepted.

Report of committee on wheels

C. T. Ripley
Chairman

During the past year the Association of Manufacturers of Chilled Car Wheels asked the Committee on Wheels to give further consideration to the clauses in the specification regarding the sulphur content requirement and the holding of wheels for check analysis. The new sulphur requirement under this specification of 0.15 per cent goes into effect in 1927 and for this reason a careful definition of the intent of the specification is necessary in order to avoid the rejection of wheels which are satisfactory for service. The balance of the various constituents is the important factor rather than any one item. There is also a possibility of small differences in the analyses made by different chemists. The committee, therefore, wishes to make the following interpretation of the chemical analysis clause in these specifications:

Sulphur Content—The essential condition of chemical composition of chilled iron wheels is a balance between sulphur, silicon, carbon and manganese, and variation in these constitutents must not disturb this relation. If on check analysis the sulphur is found to be not more than 0.02 per cent more than specified it should not be considered sufficient cause for the rejection of the wheels, provided the wheels from this foundry have met all the physical tests and inspection and provided the manganese is, at least, three and one-half times the sulphur. Such failure to meet the specification should be called to the attention of the manufacturer and following shipments or lots must conform to the specification.

In the case of the holding of wheels for check analysis, the committee also wishes to make an interpretation as follows:

Shipment of Wheels—The purchaser should not require the manufacturer to hold all lots of wheels until check analysis can be obtained unless it has been found that this particular manufacturer's output has been running outside of the specifications.

As a matter of fact, most of the railroads are following this reasonable procedure but some inspectors are interpreting the specifications in such a way as to cause an unreasonable delay in the shipments of wheels from the foundry.

The committee also has up with the manufacturers the question of reducing the flange thickness tolerance limit. The limits are now 1/16 in. over normal and 1/16 in. under normal. The committee considers this spread unnecessarily wide for good foundry practice and an investigation is now being made to see if the spread can be cut to either 1/16 in. or 3/32 in.

The committee has given further consideration to the question of increasing the thermal and drop test requirements. It has found that with the new single plate wheel, it will undoubtedly be possible to increase considerably the requirements. However, since this wheel is still in the developmental stage and is not an A. R. A. standard wheel, it does not seem best to recommend any definite change in the specification at the present time.

Grinding of wheels

During the past year a number of large grinding machines have been installed and we believe that the advantages of this practice are gradually being proved on various roads. A number of the portable grinding machines referred to in last year's report have been installed during the past year. These machines only grind a short distance to either side of the flat spot. Your committee hesitates to stand in the way of any possible saving of wheels but they cannot recommend an improper mechanical practice such as is involved in the use of these machines.

The practice of grinding the entire tread has been adopted as standard practice and is so shown in the manual. The application of wheels ground in this way to foreign cars is therefore permissible.

Wheel tape

The Manufacturers of Chilled Iron Wheels have requested the Committee on Wheels to reconsider its design of wheel tape. Some claim that they have found the A. R. A. tape unsatisfactory for use in taping wheels at their foundries. The two objections which they raise are that it is difficult to get the lugs to rest against the flange, and that the kinks in the thick steel ribbon, at points where lugs are attached, result in incorrect taping. For these reasons these foundries have continued to use the old standard tape, in which a thin ribbon is used and lugs which rest against the outside edge of the rim instead of the flange.

It is realized that the particular type of tape used is of minor importance provided the same tape is used on any two wheels mounted on an axle. Therefore, the committee is not ready to condemn the use of the old type tape for cast iron wheels at the foundries, but recommend that this question be left to arrangement between the individual railroads and wheel manufacturers. It is not felt that it is necessary at the present time to include another design of tape in the standards for use on cast iron wheels, as it has been found by most of the railroads that the A. R. A. type can be used on both steel and cast iron wheels satisfactorily. From a theoretical viewpoint at least the contact of the lugs with the flange is the correct system for taping wheels.

Chipped rim rule

Further consideration has been given to Rule 78 covering the condemnation of chipped rim cast iron wheels.

As has been mentioned in previous reports this rule is not entirely satisfactory since wheels are condemned by inspectors when they are serviceable. We recommend that the following change be made in this rule in order to clarify it:

Broken or chipped rim—If the width of the tread, measured from the flange at a point 5/8 inch above the tread, is less than 3 3/4 inches for a circumferential distance of 2 1/2 inches, unless the fracture extends obliquely through the rim toward the plate, in which case the wheel shall be removed regardless of the circumferential length of the fracture.

If this change in the rule is made, the figure on page 118 of the code should be changed to show both types of chipped rim as in Fig. 1. It will be noted that the upper sketch shows a chipped rim where the break runs outwardly in the tread. It is such cases as this that the 2 1/2 in. length feature of the new rule would cover. The lower sketch shows a break running obliquely inward toward the plate. Under the rule such a break as this would not be covered by the 2 1/2 in. length requirement.

Wheel pressure tables

At last year's convention the committee recommended an increase in the spread between the minimum and maximum allowable pressures for mounting both steel and cast iron wheels. This was done in order to get a practical shop limit table. The cast iron wheel table was only increased from 5 to 10 tons on the maximum side but the maximums in the case of steel wheels were given a considerable increase, varying from 10 tons for the small bores to 25 tons for the large bores. Before recommending these figures the committee canvassed the various roads represented and also secured the recommendations of the wheel manufacturers.

Since the adoption of this new table, the committee has been advised by one road that it considers the spread for steel wheels too wide and may result in poor workmanship. The committee has given careful consideration to this contention but feels that no change should be made in the table, at least, until further history has been developed as to results with its use.

Tread contours of steel wheels

A final report is not as yet available on the tests which committee members are running of the different tread contours on steel wheels. Figures available indicate, however, that so far as wheel wear is concerned, there is very little difference between the different contours and there is nothing to indicate that any change in the A. R. A. slope of 1 and 20 is desirable. Further report on this subject will be made when final figures are reported to your committee.

Loose wheels

Further communication has been received in regard to the loose wheel trouble. It still develops that a large percentage of the wheels which show indications of being loose, as shown by oil seepage, are actually tight on the axles. This trouble is primarily due to the use of the wrong material on the wheel fits. The shops are careless in thinning down the paint or white lead with thin oils and also permit too much slopping over on the plate of the wheel. A proper mixture of white lead and boiled linseed oil and the avoidance of the use of excess amounts will overcome the trouble.

We do not think that the painting of match lines on the axles of the wheels is of any particular benefit and may cause incorrect conclusions if the wheels are remounted at any time and the old lines not removed.

Axle gages

In last year's report, your committee gave a proposed method for the proper measurement of journal length. Since that time a considerable number of patented gages for making this measurement have been presented to the committee. We have advised all of these parties that the association could not adopt any patented gage and there was no particular need for one. Any gage which will measure the length in accordance with the diagram shown should be satisfactory. Unfortunately some of the gages presented do not measure the length correctly and we would suggest that the various railroads use care in the adoption of any such gages.

Developments in cast iron wheel designs

In last year's report the committee called attention to the apparent merits of the single plate type cast iron wheel and the association voted to permit the use of this wheel in interchange, the wheels to be marked A. R. A.-X. A drawing of this type of wheel was shown to illustrate where the extra strength was secured and statements were made as to the increased thermal test and drop test which these wheels would stand.

Since our last report, a large number of single plate wheels have gone into service. We have no way of getting exact figures but we estimate that close to 100,000 such wheels have been placed in service. On one road 26,000 such wheels were applied under new cars. A number of large roads have adopted this design as standard. All the reports which

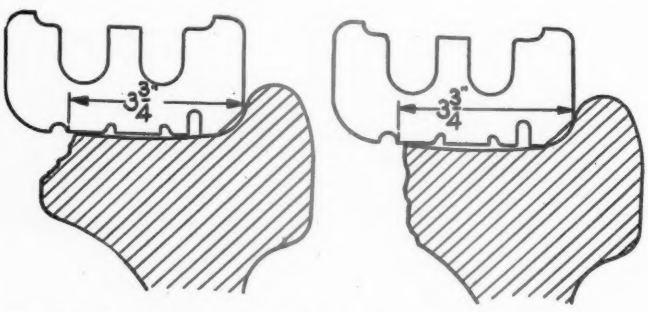


Fig. 1—Proposed revision of Fig. 5, page 118, Interchange Rules, showing the application of the wheel gage for measuring chipped rims

the committee has been able to secure indicate that the wheels are rendering better service than the double plate type. The original test of 1,000 such wheels under refrigerator cars, which was referred to in last year's report, has shown that not a single wheel of this lot has developed any inherent defects which is a remarkable performance in this particularly heavy duty service.

Laboratory tests on this single plate wheel have been made by several of the manufacturers and also by some of the railroads which show marked superiority of this design in thermal and drop tests. Your committee feels that the railroads should co-operate with those who are responsible for this forward step.

Most of the manufacturers are recommending to their customers that all of the single plate wheels purchased should have the reinforced flange. The chief obstacle to a general acceptance of this flange is the fact that it is 9/64 in. thicker than the A. R. R. standard flange. Fig. 2 shows this flange with relation to the present flange. The manufacturers have presented results of laboratory tests to justify their claims for this design, and the A. R. E. A. approved of this increased thickness, so far as it affected track conditions. It is claimed by the manufacturers of the wheels that this extra metal at this point in the flange is helpful from a foundry viewpoint in the prevention of seams in the throat, which is most important to the users of the wheels. They also presented data from laboratory tests which show that this additional metal serves a purpose so far as the flange strength is concerned, even though the breakage of the flange actually passes through the tread at the throat to the underside of the rim.

A careful review of the available facts indicates to your committee that there may be a possibility of getting better wheel service out of the reinforced flange design. The single plate design should be helpful in curing one major defect, the cracked plate, and to complete the job we should do something to help remedy the other major defect, which is the broken flange. Inasmuch as the reinforced flange will not increase the cost of wheels, it seems advisable to give the manufacturers the opportunity to do what they consider the best thing to overcome flange breakage. As a matter of fact, a considerable number of railroads have adopted the reinforced flange of various designs, as standard for their cast iron wheels and as near as we can ascertain there are about 4,000,000 of these wheels in service. Your committee has communicated with a number of these

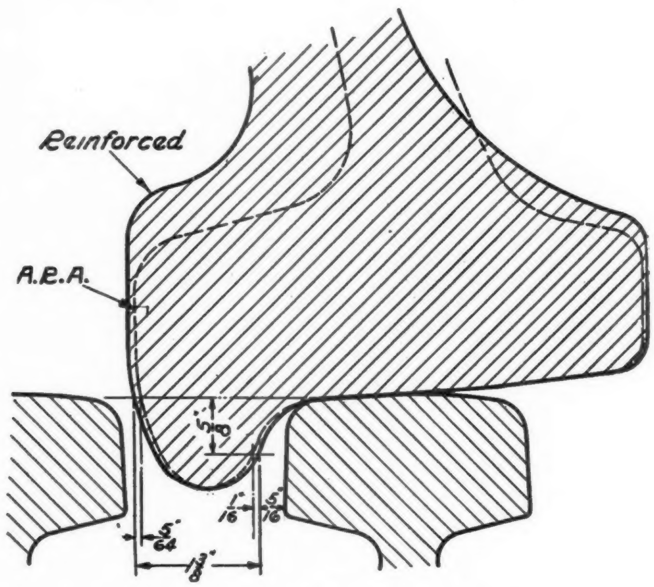


Fig. 2—The relation of the proposed reinforced flange for cast iron wheels to the standard A. R. A. flange

roads and they all report better service with this design of wheel.

In spite of this large number of wheels in service, there is no A. R. A. mounting gage which can be used for their mounting and they would be condemned in interchange if the A. R. A. mounting gage were applied. This is certainly an undesirable situation and the time has come when some action should be taken. In view of the probability of redesign of the standard wheel, as regards the plate, within the next year or two, your committee prefers to withhold recommendation that any change be made in the standard flange at the present time, as it would be better to make complete changes in design, both plate and flange at one time.

In last year's report the design of the single plate wheel included reinforcement rings. In the verbal presentation it was ex-

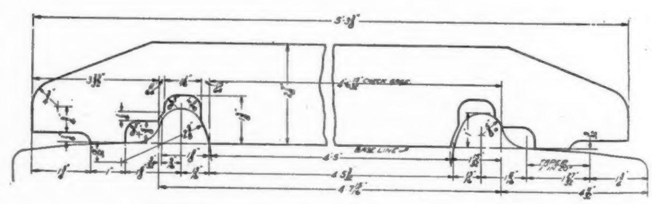


Fig. 3—Proposed mounting gage for use on reinforced flange cast iron wheels

plained that these were not a part of the design but there was some misunderstanding regarding the use of these rings. It has developed that this feature is a patented one and cannot be generally used. We are calling this to your attention in order to avoid any further misunderstanding and these rings will not be shown on any other A. R. A. prints.

The use of the lip chiller is also increasing and it seems to be the general experience that this is helpful in the prevention of chipped rims. Those roads which have adopted this feature appear to be getting better wheel service. It is the committee's understanding that while this design was patented, arrangements have been made with most of the foundries in the United States for licenses at nominal figures. The new design of single plate wheel is particularly favorable to the use of

the lip chiller due to the added metal under the rim which permits of deeper chilling at the lip.

Wheel mounting gage

Reference was made above to the necessity of having an A. R. A. mounting gage which could be used with the large number of reinforced flange wheels now in service. A chaotic condition would result if the rules regarding spacing as shown in Fig. 9, page 122, of the code were enforced and an unreasonable removal of wheels would result. The committee wishes to recommend at this time that a new gage be inserted in the standards as recommended practice for use in the mounting of reinforced flange cast iron wheels. This gage could also be used for the mounting of A. R. A. flange wheels without any track difficulties since the check gage distance is the same within

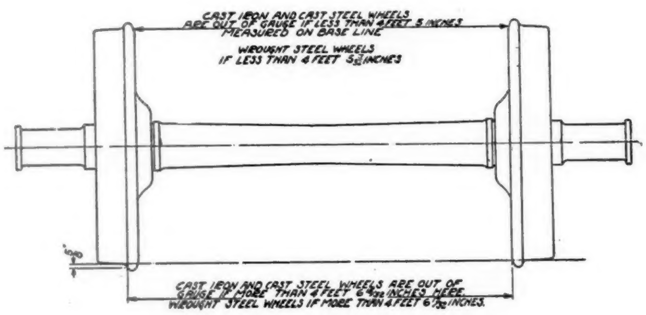


Fig. 4—Proposed revision of Fig. 9, page 122, Interchange Rules, showing the mounting dimension limits

1/64 in. for both gages and this check gage distance from the throat of one flange to the back of the other flange is the governing factor so far as the track is concerned. Fig. 3, shows the gage which is recommended. It will be noted that the minimum back to back distance is reduced from 4 ft. 5 3/32 in. to 4 ft. 5 in., which incidentally is the present minimum limit in the I. C. C. rules. The check gage distance is changed from 4 ft. 6 29/64 in. to 4 ft. 6 15/32 in., in order to eliminate the 1/64-in. dimension. If the normal reinforced flange is 1⅜ in. at the base line and a tolerance of only 1/32 in. over normal is permitted, there will be a 1/16 in. clearance at each end of the gage when used on a maximum flange, which is the same as the present gage used on a maximum A. R. A. flange.

It will also be necessary to change the requirements of the rules, as shown in Fig. 9, page 122, of the code, by making the maximum throat to back distance 4 ft. 6 15/32 in. and the minimum back to back distance 4 ft. 5 in. The latter figure agrees with the I. C. C. rule. Prior to 1909 the association had more than one gage for use in mounting; that is, there was a mounting gage, a reference gage, and a check gage which is probably the ideal system of gaging. However, your committee does not feel that they should do anything to complicate this gage situation as it is hard enough to make the operators use one gage correctly and there is a large cost involved in changing all of the gages. The recommended gage can, if desired, be made from the old gage and thus very little expense is involved. Fig. 4 shows the proposed revision of Fig. 9, page 122. It will be noted that the limiting dimensions above referred to are shown as applying only to cast iron and cast steel wheels and that another set of limiting dimensions are shown for wrought steel wheels. It is necessary to have different dimensions for the wrought steel wheels because of the fact that the flanges are of different thickness and also to make proper allowance for the fact that when steel wheels are turned, the flanges are thus restored to the full contour of the wheel.

The committee in its 1926 report submitted a design for a steel wheel mounting gage, in which the back to back measurement is a governing factor. There is at the present time no gage in the A. R. A. standards for use in the mounting of steel wheels. After further experience with the use of this mounting gage, the Committee on Wheels now makes the recommendation that it be put in the manual as recommended practice. Fig. 5 illustrates this gage.

The second paragraph of Rule 24 prohibits the mounting of two wheels on the same axle where the thickness of the two flanges combined exceeds the thickness of one normal and one maximum flange. In view of the action of the committee in establishing a new mounting gage for use on reinforced flange wheels, it appears that this paragraph is not necessary in the rules. It is therefore recommended that it be eliminated.

Wheel defect gage

The attention of your committee has been called to the fact that a number of wheel defect gages have been turned out by the gage manufacturers which have the wrong radius at the corner for measuring the vertical flange. The A. R. A. drawing, as shown on page 110 of the code, does not show a radius dimension, though it is evident that the radius should be ⅞ in., as is shown in the proceedings. For some reason this dimension was left off the drawing and should be restored at the next revision of the manual. The use of any other radius will give an incorrect measurement of the vertical flange.

In this connection, the committee wishes to call attention to the fact that enough care is not being used in the manufacture of new gages of all kinds. A number of gages have been called to the attention of the committee which were not made in accordance with the A. R. A. drawings. Some of the manufacturers apparently have not realized the importance of accuracy in the manufacture of such gages and the railroads have not realized the importance of checking all new gages before placing them in use. The practice followed by some of the railroads is to have all new gages checked over by the engineer of tests, or other designated official, and after being passed by him, stamped as correct. Your committee recommends that the railroads consider some such procedure as this. It may also prove desirable to have a master gage of each type held in the office of the secretary of the Mechanical Division, in order that any of the roads may check their master gages and thus insure absolute uniformity.

The committee does not think it necessary to change the wheel defect gage for use on reinforced flange wheels at the present time. Ultimately as these wheels come into general use, the gage can, if necessary, be changed so that the flange thickness limit will be 1⅛ in. instead of the present 1 in. The use of two different gages would be confusing, as the inspectors might have trouble in differentiating between the A. R. A. flange and the reinforced flange. As a matter of fact, the vertical flange limit of ⅞ in. is the real condemning factor in cast iron wheels and the reinforced flange wheels will be caught by this limit before they reach the one-inch thin flange limit. It will, however, be necessary to provide a new gage for maximum flange for reinforced wheels as shown in Fig. 6. This gage is used only by inspectors at the foundries and provides for a maximum flange thickness of 1 13/32 in.

Braking power of refrigerator cars

Your committee has in previous reports referred to the effect on wheel service of the high braking power ordinarily applied

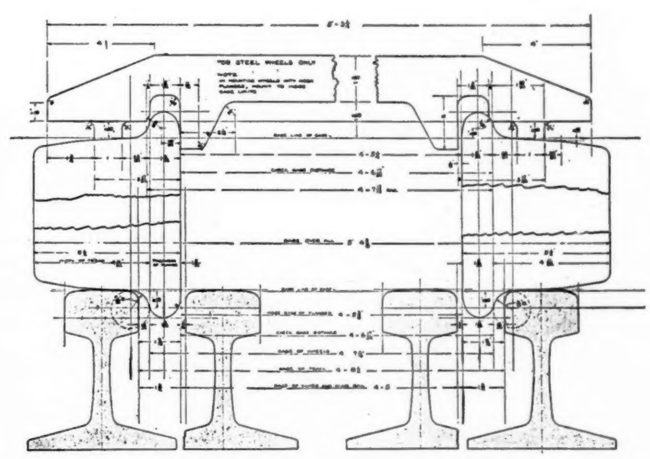


Fig. 5—Proposed mounting gage for wrought steel wheels

to refrigerator cars and other cars of high light weight. Under the present system of brake design these cars do an unreasonably large proportion of the braking for the train. The result is that the wheels are subjected to high stresses in the plate and the treads develop brake burns rapidly. If the braking power on these types of cars could be reduced so that it would be more nearly equal to that of other cars, there would be less plate breakage in wheels and also a considerable saving due to the reduction in the number of wheels removed for brake burn.

This question has been referred to the Committee on Brakes

and Brake Equipment and it is hoped that prompt action will be taken by this committee toward finding a solution.

The wheel manual

A number of suggestions have been made for changes in the tentative wheel manual, which was presented in 1925. However, the final results of the study of steel wheel defects is not as yet available and in view of this fact and also the possibility of some major changes in standard cast iron wheel designs and gages for the same, it does not appear desirable for the committee to issue the final manual at the present time.

It may be mentioned that a very large amount of work has been done by the sub-committee of your committee during the past year in an exhaustive investigation and study of steel wheel defects. There are many difficult questions involved in this study. A committee of the manufacturers and this subcommittee

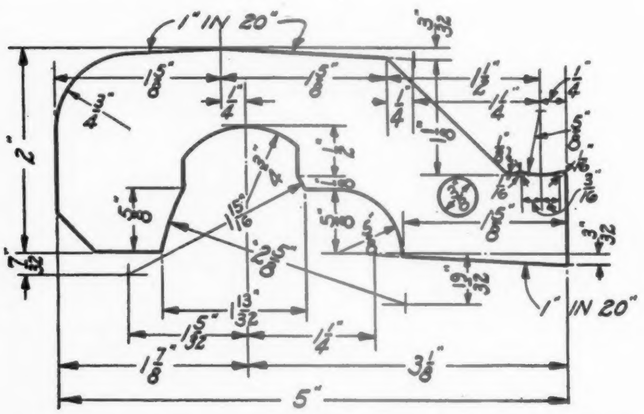


Fig. 6—Proposed maximum flange gage for reinforced flange cast iron wheels

have gone over defective wheels and a complete record has been made of the same. The laboratory study of these wheels is not as yet completed but it is hoped that out of this study we may be able to present to you a definite classification and definition of the various steel wheel defects which will help to clear up the confusion which now exists in this regard. We wish to acknowledge the active co-operation and assistance of the manufacturers in this important work. We regret that the final results are not in shape for presentation in this report but we consider the subject of such importance that we wish to have the complete data available before their presentation to the association.

Conclusion

The committee recommends submission to letter ballot of the following items which have been discussed in this report:

(1) Adoption as recommended practice, mounting gage for reinforced flange cast iron wheels.

(2) Adoption as recommended practice, maximum flange gage for reinforced flange cast iron wheels.

(3) Adoption as recommended practice, mounting gage for wrought steel wheels.

The report was signed by C. T. Ripley, (chairman), chief mechanical engineer, Atchison, Topeka & Santa Fe; O. C. Cromwell, assistant to chief of motive power, Baltimore & Ohio; H. W. Ostrom, chief chemist, Chicago, Milwaukee & St. Paul; G. B. Koch, general foreman foundry, Pennsylvania; H. W. Coddington, engineer of tests, Norfolk & Western; A. Knapp, inspection engineer, New York Central, and John Matthes, chief car inspector, Wabash.

Discussion

The greater part of the discussion dwelt on the subjects of single plate and reinforced flanged cast iron wheels, during which several railway men stated that their roads have been using these wheels for many years without receiving any serious complaints. The question was asked as to whether any road had experienced difficulty in maintaining the A. R. A. mounting pressures when using single plate wheels. In answer to this question Mr. Ripley, the chairman of the committee, admitted that some hubs have broken at the outside end during mounting, but the trouble was confined to the products of a few foundries which have taken steps to remedy it. A total of 26,000 of these wheels, the product of four foundries, have been mounted recently and not a single case of hub trouble developed, he said. Has any change been necessary in the mixture of the steel to maintain the proper chill, was the next question asked. Mr. Ripley stated that manufacturers do not feel that the single plate wheel design should in itself alter the chill to any great extent. The real trouble is the fact that the mass of metal at the hub is more subject to the drawn hub defect which the manufacturers are making progress in eliminating.

The remainder of the discussion centered on the eccentric grinding of flat spots on car wheels. W. E. Dunham (C. & N. W.) stated that a large number of wheels has been reclaimed by this method of grinding and that these wheels have met the requirements of the rotund gage and were not over 1/32 in. out of round. He admitted that eccentric grinding can be carried to extremes, but believes that with limitations it will bring about a great deal of economy to the railroads. The chairman of the committee admitted that some roads are using the portable grinders with marked success, but they are not dependable and there are machines available to do the work right at a low cost. Two machines in the year 1926 on one railroad netted $55,000 profit, he said. John Purcell (A. T. & S. F.) stated that in 1912 a campaign was started to reduce the number of slid-flat wheels and at the same time attention was directed toward the truing up of wheels. Since that time he said that the number of slid-flat wheels has been reduced 60 per cent. He concluded by stating that he hoped the time was coming when every railroad on the American continent would grind every wheel before placing it under a freight car.

The report was accepted and referred to letter ballot.

Report on lubrication of cars and locomotives

G. W. Ditmore
Chairman

The purpose of this committee is to make an investigation of the general lubrication of railway equipment. The major consideration leading to the appointment of the committee was the proposed revision of Interchange Rule 66, covering the periodical repacking of journal boxes, which was approved at the annual meeting of the division last June. The committee was instructed to give attention to specifications for the following: (a) Packing journal boxes; (b) lubricating oils, and (c) oil reclamation.

The methods of packing journal boxes was first given attention, based upon the "Recommended Practice," adopted by the division in 1920. The Committee has prepared a revision of the "Standard Method of Packing Journal Boxes," adopted as Recommended Practice, in 1920, and now recommends Exhibit A for advancement and adoption as Standard Practice.

Saturation of waste

A mechanical method of saturating waste for journal packing is commonly practiced, which simply allows the waste to soak in warm oil a sufficient time to absorb the necessary amount of oil. A long time is required by this process to saturate new waste in order to completely impregnate the fibre, because of the confined particles of air within the fibres. It is necessary to remove the air to permit complete saturation. A vacuum process will accomplish this operation at a great saving of time. The reason for requiring that the oil be extracted from the packing is, that it may be reclaimed and eliminate the dirt from the oil, resulting, also, in economy in the cost of journal lubrication.

Reclamation of packing

The reclamation of waste from journal box packing and the preparation of the packing should be done at a central plant according to the requirements of a given railroad system. All journal packing should be handled in closed metal containers to and from the reclamation plant. The back rolls and the front wedges, or plugs, should also be prepared centrally, and shipped with the packing. The reasons for handling at central points are to secure a uniformly better product, and to obtain a lower cost of preparation consistent with the better product. An objection may be claimed that the cost of handling will be increased, but it is believed that the improved results obtainable will justify the increased handling charges.

Reclamation plant for journal packing and oil

The committee has visited one of the reclamation plants on one of the large railway systems.

The old journal packing is shipped there from all points in the district in steel drums. These are first weighed. After the packing is picked over, and lumps pulled apart, it is put into a vat of hot oil for a few minutes, stirred with a fork and placed on a drain board. This process removes most of the fine dirt and some of the short ends and babbitt pieces and washes the waste.

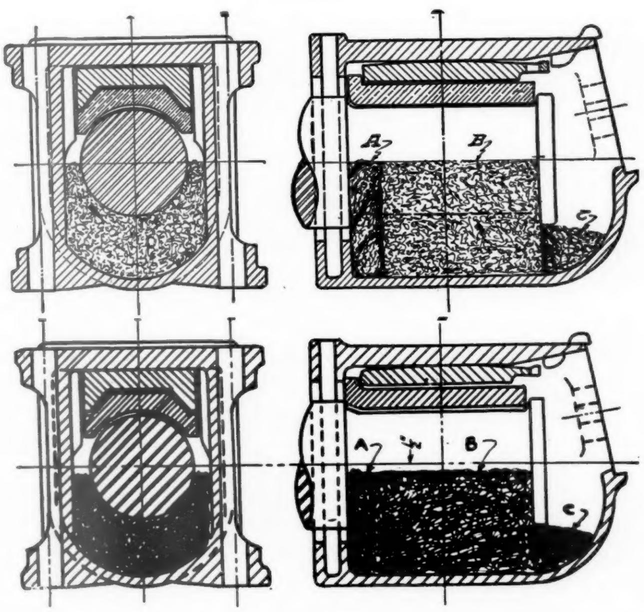


Fig. 1—Drawings showing the present recommended and the proposed methods of packing journal boxes

It is then put into a centrifugal machine and the oil extracted. The waste is transferred to a laundry machine consisting of a horizontal cylinder of woven wire screen and operated in a combined rotary and oscillating motion, thus "rumbling" the waste and sifting out the dirt and short ends. The waste is also subjected to a warm air blast to remove the moisture and restore resilience. It is then placed on a tray having a coarse screen at the bottom, and is loosened by hand over the screen, when it is transferred to the saturating machine.

In the saturation process a known weight of waste is thoroughly impregnated with a known quantity of cleaned oil in about two minutes by the use of a vacuum and pressure method.

The prepared packing is then put into steel drums, weighed and is ready for shipment.

Oil reclamation

The oil constitutes 80 per cent of the product used for lubricating journals. Therefore, it is essential that the oil be as free from contamination as the waste which conveys it to the journal.

Dirty car oil will contain from 2 to 15 per cent of moisture and freewater and from 5 to 12 per cent of ash, i.e., grit and solid matter.

By good filtering processes it is possible to greatly improve the condition of the oil, reducing grit and solids to less than 5 per cent, but without eliminating the moisture.

Three methods are used at present for reclaiming the oil extracted from journal packing.

Filtering—Various mechanical types of oil filters are in service on some roads employing strainers or straining materials, or both. This process eliminates most of the dirt and solids.

Separating—The centrifugal method, utilizing machines of the cream separator type, are also employed, and frequently are used after the oil has been filterd.

Heating the oil to the boiling point, to drive off the water, where practical, must be done carefully to avoid explosions and scattering of the fluid.

Chemical—In connection with filtration there may be added a chemical process which breaks down the emulsion formed after heating and stirring of dirty oil and eliminates the moisture after the free water has been removed. This method is, undoubtedly, an advance step in successfully restoring oil to its original condition, rendering it as serviceable for lubrication of new oil. This chemical and renovating treatment employs, successively, a series of tanks for collecting the old oil from the cleaning vats, treating it with chemicals, evaporating the moisture, separation of solid matter and for storage. The filtering or the separating processes will render the oil about 95 per cent pure, while the chemical will produce an oil over 99 per cent pure.

The committee's conclusion is that any of these three methods may be utilized with resulting improvement and economy over the simpler methods frequently employed.

Application of packing

In the application of packing to the boxes, the Committee feels that the improvements will result from the changes outlined, as follows:

a—The back roll is specified 3 in. diam. to insure ample size to make contact on the journal fillet and exclude the dust. The lengths of roll will vary to suit the diameter of journals.

b—The proposed rule describes a good method of forming packing in one piece, keeping the top of packing a half inch below the center line of journal. This is already the practice on many roads, to avoid waste rolling under the bearing.

c—The committee recommends the use of the wedge, or roll, at the outer end of the journal box. While a few roads do not use it in packing their own boxes, the majority of roads do use it, and some of the roads running through extremely sandy territory insist that such wedge is necessary to seal the box against excessive dirt.

Inspection

The importance of proper methods of packing journal boxes requires that the employees performing this work be fully instructed. It is suggested that a full sized model be used for the better instruction of journal packers. The model of the box should contain the journal, the journal bearing and the wedge. Both sides of the box should be provided with doors, or slides, covering glazed openings for the observation of the interior. Demonstrations with this model would illustrate clearly the right method of applying packing.

Rules for inspection of journal boxes are submitted in Exhibit D.

Locomotive lubrication

The committee can only report progress on the studies of locomotive lubrication. It is preparing to assemble information for development for next year's report, provided the commitee is continued.

The report is signed by G. W. Ditmore (chairman), Delaware & Hudson; H. W. Johnson, Minneapolis and St. Louis; P. Maddox, Chesapeake & Ohio; T. O. Sechrist, Louisville & Nashville; G. E. Dailey, Chicago, Burlington & Quincy; M. J. O'Connor, New York Central and C B. Smith, Boston & Maine.

Exhibit A—Method of packing journal boxes

(The proposed Standard Practice is a revision of that adopted in 1920, instructions being clarified and amplified. Instructions for preparation of renovated packing have been added to and should insure better results. Bored or broached bearings are called for and instructions added relative to worn or defective wedges. Rules for application of packing have been extended and improved.—*Editor.*)

Exhibit B—Specifications for dust guards

Purpose—To exclude dust from the journal box and to retain the oil.

Requirements—To serve its purpose the guard must fit the axle tightly at all times.

Material—Must be flexible in the portion in contact with the axle in order to take up wear as it occurs and such portion must be resilient and durable. No metallic portion of guard, if used, shall be allowed to come in contact with the axle during the life of the guard. Material must be heat-resisting and non-breakable in service. The guard must be easily applied.

A wedge or plug shall be applied to close the top of the guard-well in the box, or provision made in the construction of the guard to close this opening in order to exclude dirt.

Service—The service life of the guard shall be equal at least to the

service life of a pair of new wheels. The common wood dust guard shall not be considered as complying with these specifications.

Exhibit C—Specifications for journal box packing tools

Two packing tools (shown in Fig. 2) are required for packing journal boxes.

The packing iron is used for inserting packing and pushing it into proper place in the box. This tool should be 24 in. to 30 in. long, and made of 5/8-in. round steel of 0.3 to 0.4 carbon to insure holding its proper shape in service. The blade or spoon portion should be 14 in. long to permit proper packing of the longest journals. The blade should be provided with suitable curve and offset to permit working the tool properly inside of the journal box. A "fish-tail," 1¼ in. by ⅛ in. should be formed at the end of the blade, to facilitate pushing the packing into place. A lug for lifting and closing box lids conveniently should be provided on the shank at least 15 in. from the end of blade. The handle should be formed by bending the iron into an oblong loop 4½ in. by 1¾ in. outside dimensions, and centrally located at the end.

The hook is used for withdrawing packing from box and pulling out wedge and bearing. It should be about 24 in. long, of ⅜ in. round medium steel and provided with a handle similar to packing blade. The hook end should be first tapered for about 12 in. from end to lighten the weight and to permit easy access between wedge and journal. The hook, about 1¼ in. long, should be formed by bending the end at a right angle.

Exhibit D—Inspection of journal boxes

An inspection shall be made by raising the box lid and examining parts and conditions as follows:

1—Feel in the back of the box with a packing tool to see if packing has worked away from the fillet of the journal.

2—If the packing has settled away, it must be set up to the journal with the packing tool.

3—If the packing is found to be glazed on surface in contact with the journal, the surface should be broken up with the packing blade and the waste worked over to bring a fresh surface against the journal, being careful that loose ends are tucked in.

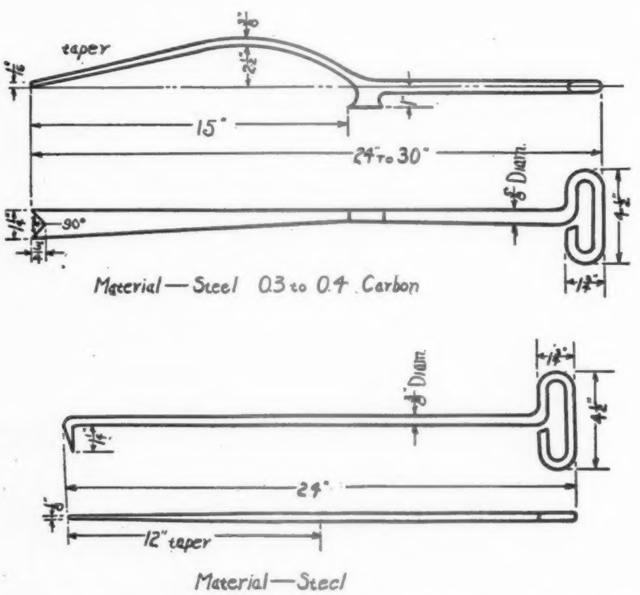


Fig. 2—Recommended design for journal box packing tools

4—The top of the packing should be kept not over a half-inch below the center line of journal.

5—When removing the outer wedge, or plug, it must be kept separately, to avoid getting dirt from it into the packing.

6—When pin-grease or any other cooling compound is found mixed with the packing, all such packing must be removed and the box repacked with fresh packing.

Such compounds, which will lubricate a hot box after it is too hot for oil lubrication, will, if left in the box, cake over and prevent oil feeding up through the packing.

7—If packing contains water, the box should be repacked.

8—The end of the journal must be inspected carefully to note its condition.

When the center is found to be dry, it indicates there is poor lubrication, defective journal bearing or dry packing, and the bearing should be removed for careful inspection, and renewed, if defective.

9—When bearings have to be renewed on account of heating, a careful examination shall be made of the condition of the journal before applying the brass.

10—The brass must be examined to determine if the lining is squeezed or broken out. This may be done by running the packing hook along the lower edge of the brass.

11—The end of the brass must be examined to determine if it is broken or cracked.

12—See if brass and wedge are in proper positions.

13—After inspection is completed, no strands of packing should be left hanging out of the box, and box lid must be closed tightly, to exclude dust.

Discussion

As this was the first time that this committee had presented a report, considerable discussion resulted. Exception was taken to the recommendation that the back roll should be 3 in. in diameter by M. J. O'Connor (N. Y. C.) who stated that years of experience in handling rolls have demonstrated that a roll 2½ in. in diameter and 10 in. in length is more serviceable. He stated further that the use of a wedge, or so-called dirt seal, has proved superfluous and interferes with the proper adjustment of packing on cars in train yards for the reason that the yard forces and time are each usually limited.

E. Von Bergen (I. C.) made some constructive criticisms and definite recommendations, which are given below in full.

Specification No. 3 is somewhat indefinite, if a so-called compensating or adjustable dust guard alone is specified, it is not advisable, as a one-piece composition flexible guard with not more than 1/32-in. clearance on the axle will be found just as efficient as a laminated wood adjustable guard.

Under proposed Rules 1 and 6 of the proposed method of packing journal boxes employees who prepare packing are likely to drain it too dry. To make clear to them the proper condition of completed packing, the following sentence should be added—"Oil should not drip from drained packing when lifted from the draining rack, but oil should flow from it when squeezed in the hand."

Proposed Rule 12 specifies the method of forming the back roll. These rolls can be spun on a motor driven spindle, and the product is equally as good as though hand-made and twine bound and at much lower cost. This should be optional.

Proposed Rule 12 (b) specifies when applying packing between back roll and wedge or dirt seal, to allow strands to hang down outside always adding more packing before placing the hanging strands inside the box. There is serious doubt that this is good practice. The only purpose these overhanging strands serve, is to drag dirt clinging to the outside of the box, into the box.

The speaker continued by recommending that the committee be instructed to study the following conditions and method suggested for correction, to be incorporated in Rule 66, and report their recommendations to the convention in 1928:

1—A large force of oilers or box packers is employed in train yards by each railroad for the purpose of giving so-called attention to journal boxes. Ninety per cent of the work of these men consists of hurrying along the side of a train, and jabbing the front plugs with the packing paddle. This work is worthless and such journal boxes would be as well off if these men stayed at home. In fact, in most cases the boxes would be better off, as the front plug is nearly always coated with dust, and these men punch it under the journal, sooner or later causing a hot box. With the high speed movement of freight trains through terminals today, the train yard is no place to work journal boxes.

Remedy—Take the oilers out of the train yard and put them on the repair tracks. One man can properly repack five times as many boxes on a repair track as he can in a train yard during a given period of time on account of the time lost in walking long distances to and from the soaking vat or dope house to the cars in train yards. In addition to the annual repacking of journal boxes on repair tracks required by Rule 66, provide for pulling and repacking journal boxes each time cars are on repair tracks for any other cause when the packing stencil is more than three months old, this work to be charged to car owner. Twelve months is entirely too long to expect packing to function successfully.

2—The work of adjusting packing in journal boxes on in-date cars on repair tracks, if done at all, is now largely performed in a slipshod manner, and little, if

any, benefit is derived from it. This lack of proper attention is a prolific source of many hot boxes.

Remedy—Add to Rule 66 specific instructions covering the manner in which this work must be performed as follows: Insert a wire or slender packing hook as a feeler to determine if packing is firmly in contact with the journal all the way back and if the back roll is in position. If not, or if the packing is above the center line of the journal on the sides, remove the front plug and work the packing into the proper position, then firmly replace the front plug. Do this each time cars are on repair tracks, for other causes and at handling lines' expense.

3—Thousands of hot boxes develop on account of defective bearing linings. Car inspectors are unable to detect these by the ordinary visual inspection followed on practically all railroads. On one railroad in one train yard recently 94 defective linings were found in four days with the use of a feeler, that could not be detected by visual inspection. These defects consisted of linings broken, loose or spreading.

The source of this trouble is relining bearings without boring the shell, as a proper bond between babbitt lining and shell cannot be made when the old lining is merely melted out and the shell-tinned and melted babbitt poured on. Aside from this, many railroad shops where bearing shells are relined have no facilities for determining the proper quality of the babbitt used or the proper melting heats.

Remedy—Adopt a rule prohibiting the use of any relined journal bearings, as the cost of a new 5-in. by 9-in. journal bearing is only approximately 35 cents greater than the cost of relining, the benefits derived fully warrant the casting all bearings in which the lining is worn out or defective. If it is decided to continue relining, then it should be mandatory that the old shell be bored with at least a 1/32-in. cut after the old lining is melted out and before relining.

4—Many cars are sent off repair track with defective bearings or cut journals, the latter because when the car was inspected at interchange it could not be plainly seen that the journal had been hot. This results in more hot boxes.

Remedy—Adopt a rule providing for inspecting journals and bearings with a feeler while cars are on the repair track, and replace any defective bearings or cut journals found, the expense to be charged to the owner, except where packing stencil is less than three months old, in which case the road which applied the stencil shall be responsible for the charges.

The report was accepted and the committee continued.

Report on couplers and draft gears

R. L. Kleine
Chairman

Believing that a brief account of the status of the A. R. A. draft gear tests will be of interest, the following progress report is submitted. Our report of last year mentioned the fact that it had been decided by the General Committee that the drop test machine was to be located at Purdue University, Lafayette, Indiana, and that the order for the drop test machine had been placed with the Tinius Olsen Testing Machine Company.

The final shipment of parts of the drop test machine was made in April and the erection in the building provided for the purpose, as well as the installation of the electrical mechanism, wiring, etc,. is under way.

The building, is 25 ft. by 50 ft., of brick construction, architecturally in harmony with the University buildings, and being used solely for draft gear testing, was designed with that end in view.

The draft gear testing machine is equipped with two tups, one weighing 9,000 lb. and the other 27,000 lb., both of which will be used in the tests. The former will be used in obtaining the recoil of the draft gears and also the capacity and other characteristics of a portion of the draft gears of each design in order that if desired, comparisons may be made with tests made elsewhere, as generally speaking a 9,000-lb. tup has been used. The 27,000-lb. tup has the advantage of a lower velocity at moment of impact than the 9,000-lb. tup when delivering a blow of a given number of foot-pounds and more nearly approaches the speed of cars when being coupled and for this reason it will be used throughout the tests, except as previously referred to.

The movable guides which are secured to the main columns permit the substitution of one tup for the other with a minimum amount of labor, and without dismantling the columns. The machine is electrically operated, and so designed that in addition to complete manual control, certain functions that permit of such arrangement are semi-automatic. A chronograph is provided for recording the action of the draft gear being tested throughout the cycle of compression and release.

From the data obtained in connection with these tests, the following information and characteristics of the draft gears will be available: Capacity, recoil, sturdiness, endurance, smoothness of action, cushioning value, and uniformity of product, and based upon these results, specifications will be prepared under which, when approved by the association, the railroads may purchase draft gears that are known to meet the required standards of efficiency.

After working out the proposed methods to be followed in testing draft gears, the plans were submitted to the manufacturers for the benefit of their suggestions and criticisms, all of which were carefully considered, and where favorably thought of, embodied in the proposed method of conducting the tests.

It is expected that the draft gear tests will be started during the latter part of May and that approximately two years will be required for their completion. The draft gear tests will be conducted under the supervision of your committee and will be in charge of Dean A. A. Potter of the Schools of Engineering and director of the Purdue Engineering Experiment Station and W. E. Gray, engineer of draft gear testing. All of those actually engaged in the testing work will be in the employ of the University.

The interest taken by draft gear manufacturers in developing their products is indicated by the improvements in detail design as well as new designs, some embodying entirely new principles that have been brought out within a comparatively recent date. In addition to the information on draft gear performance that will be available as a result of the A. R. A. tests and the benefits that may be expected from the adoption of specifications for draft gears, it is hoped that the testing machine will be of great assistance in improving design and in developing experimental gears.

Under the terms of agreement with Purdue University, manufacturers of draft gears desiring tests or other research work on the A. R. A. draft gear testing machine may have such work undertaken when the testing machine is not engaged in A. R. A. work by making suitable arrangements with the Purdue University authorities. It is felt that the opportunity thus offered the manufacturers will be helpful in the further development of this important detail of cars and locomotives.

The report is signed by R. L. Kleine (chairman), Pennsylvania Railroad; C. P. Van Gundy, Baltimore & Ohio; C. J. Scudder, Delaware, Lackawanna & Western; H. W. Coddington, Norfolk & Western; C. B. Young, Chicago, Burlington & Quincy; Samuel Lynn, Pittsburgh & Lake Erie; L. P. Michael, Chicago & North Western; E. A. Gilbert, Southern Pacific; and M. A. Hall, Kansas City Southern.

Discussion

The chairman of the committee supplemented the information contained in the report by stating that when the tests are started, a number of days will be set aside for the members to visit the testing laboratory, during which time no official tests will be made. The members will be notified by circulars. No information will be given out until the completion of the tests, and representatives of the draft gear manufacturers shall be excluded from the laboratory. When the tests are completed, the draft gear committee will report on the tests to the association which will then make public the re-

sults. The members of the draft gear committee are welcome to visit the testing room at any and all times.

On motion the report was received.

Passenger car construction

By G. E. Smart

Chief of car equipment, Canadian National

G. E. Smart

Owing to demands for better, more luxurious and convenient modes of transportation, the designing of passenger cars has become a serious problem, particularly for sleeping cars and cars of the higher class. It would seem that the limit has been reached insofar as size and dead weight are concerned and that further developments would have to be along the lines of decreased weight, more economical use of available space and use of devices to minimize tractive effort required for moving such equipment.

When one considers the proportion of dead weight per passenger, it would be out of the question to decrease the present size of passenger cars, particularly if it in any way reduced the passenger accommodation. Then, owing to the present difficulty of negotiating curves, it would seem that the maximum length has been reached, so it would therefore be reasonable to suppose that the present length, width and height would have to be maintained for some time to come.

Dead weight

As to weight, this is a detail which cannot receive too much consideration. For instance, taking the present standard sleeping car and the average load, for every passenger the railroads are hauling approximately seven to eight tons of dead weight which, on the face of it, is most uneconomical. However, this has been brought about by the demands of the traveling public and also a desire of railroad officials to provide as safe means of transportation as possible. In any attempt to decrease the weight of present equipment it must not be to the detriment of strength and safety, as, while cars are not designed for operation off the rails, the fact remains that we must guard against the possibility of injury due to collisions and derailments, and safety is, and should remain, the first consideration.

The seriousness of dead weight cannot be over-emphasized and there should be great possibilities for designers by the introduction of steel with considerable greater ultimate strength, or some other material which would be equal to the strength of the open hearth steel now used but considerably lighter and which could be produced at a price to warrant its use. In addition to reducing dead weight without seriously affecting the strength, another important factor which must not be overlooked is the final cost, as this has a direct bearing on the revenue producing value of the car. There surely is a great field for investigation and development of some such material.

Corrosion of steel coaches

Almost of equal importance to the strength and weight of this material would be its rust-resisting qualities as all roads, I think, are finding now, and particularly in the earlier constructed steel passenger cars, that they are showing deterioration, especially in the side sheets, roof and flooring, to such an extent as to make this a serious matter and one which should be carefully considered in selection of materials.

There are also great possibilities of dead weight reduction by the use of articulated cars. In Europe they have, in some instances, articulated the whole train, thereby making a considerable saving in weight and also in cost of construction, but it is a question whether the articulated principle can be adopted to the same extent in this country, particularly in main line service, as the cars must be used in trains kept as one unit during their entire trip. On trains which have to be disturbed the use of the articulated principle would be impractical. There should, however, be possibilities for this equipment in suburban trains or other places where the service required is uniform, for trains between two large centers, and where the cars could be kept in a particular service.

Roller bearings

The roller bearing is a live question and a number of roads are testing out different types. From the results so far it would seem that further exhaustive tests should be made with the idea of finally perfecting the design to such an extent as to warrant its universal use, as the saving in tractive effort required in handling a train equipped with roller bearings is so considerable that it may eventually reduce the power unit.

The use of roller bearings means in many cases a change in the pedestal, increasing the width between the jaws so as to provide room for a bearing of proper design and strength. On new cars this can easily be arranged without additional expense, but on existing equipment it means, in most cases, changing pedestals and redesigning equalizers. Eventually I believe that only one or possibly two designs will be standard so that equipment can be interchanged without having to keep various types of axles and boxes for use when wheels are changed.

To analyze completely present design and construction in all details would require a paper of a length impractical for this meeting and I have, therefore, only touched on a few items which seem to be most important. I feel that the greater possibilities for immediate improvement in passenger car construction are the use of suitable roller bearings, and the use of lighter material to replace the grade of steel which we are now using. However, I would like to mention, briefly, a few other details which warrant thought.

We now lock the body of the car to the center truck bolster, but this member is attached to the cross bolsters by only a few bolts. Would it not be advisable to combine these castings into one and thereby carry out the principle of locking the body securely to the truck as a matter of positive safety?

A suggestion for lighter sleeping cars

In view of the small average number of passengers carried in sleeping cars, would it not be advisable to eliminate the upper berths, thereby saving considerable weight equipment such as bedding, and cost of construction? This would make it possible to use turtle-back roofs, thereby still further reducing weight and cost.

The use of steel for roofs is objectionable from a maintenance standpoint, due to rapid deterioration, but makes a lighter construction than wood and canvas. The steel roof eliminates creaking due to its rigidity and reduces weight by dispensing with the great amount of furring necessary for the attachment of the roof.

Passenger and freight car design

By Victor Willoughby

General mechanical engineer, American Car and Foundry Company

V. Willoughby

The transportation facilities of a nation have always provided an accurate gage of its prosperity. The solving of a transportation problem calls for a careful analysis of the products or people to be transported, length of haul and density of traffic. Not many years ago we were almost entirely dependent upon railroads or steamships as our transporting mediums over any except the shortest distances. The advent of the motor truck has materially changed the short haul freight problem, while the privately owned automobile, together with the bus lines, are giving all except the long-haul freight and trunk line passenger service a hard struggle for existence.

The automobile has probably been one of the best educators that has ever been invented and its use has so stimulated passenger travel that our desires are becoming more and more cosmopolitan. Take the dining table of today versus that of 30 or 40 years ago and you will find on even the most humble table products from all over the world. These were luxuries three or four decades ago; today they are felt to be absolute necessities. All this means additional traffic for our transportation facilities to handle and the equipment must be that most suitably adapted for its traffic.

Refrigerator cars

The refrigerator car must take the melons of Colorado or California, place them in New York or Boston in the pink of condition, and the charge for this service must not be exorbitant. Every pound dead weight which this car contains entails the use of extra energy for its transportation. This energy comes from the coal pile. Therefore, one of the car designers first

problems is to keep the weight of the car as low as possible, all things considered.

In order to deliver perishable produce in the pink of condition it must be kept during the days which it is being transported within a narrow range of temperature both day and night, even though the outside temperature may vary as much as 50 to 80 deg. Two important elements of design enter into the proper maintaining of this temperature: (a) the refrigerating agent, and (b) proper insulation of the car.

The refrigerating agent in general practice is melting ice. The cost of this is a transportation charge against the product and may be divided into several parts, such as cost of the ice and salt; cost of handling the ice; transportation of this ice, it being an additional dead load; and the damage that the salt water can do to the car and the roadbed. Therefore, in designing this car it is extremely important that care be taken to conserve so far as possible this refrigerating effort by proper insulation.

Take the design of the insulation; laboratory tests have been made on a large variety of insulating materials. These tests are useful, but are reliable guides only insofar as the insulating material is applied to the car in such a manner that it will stay where put. A new wooden-frame refrigerator car with all joints between the insulation tight and connections between outer and inner walls properly insulated, will give results very close to those indicated by laboratory tests. If, however, in the course of operation the joints open up, insulation slips from place, leaving open spots, then the efficiency of the car deteriorates rapidly.

The designer must be careful to see that his construction is such that this insulation will stay where put during the normal life of the car. In doing this he must not overlook the element of weight, because every pound increase in dead weight means a certain amount of coal wastefully used.

Thus, due consideration must be given when deciding upon the kind of insulation as to its insulation value versus its weight, versus the ease with which it can be properly secured in a car structure, versus its susceptibility to moisture, and its relative cost weighed against all these elements. A refrigerator car designer has to take all these factors into consideration if he hopes to have a design that will successfully compete in the transportation game. He even should go further and consider the color of paint used on the car, especially the roof, as this has a large influence on heat radiation and heat absorption.

Box cars

Taking the box or house car, first consideration must be given as to what product is most likely to be hauled. The designer who does not consider the predominating commodity that the car has to transport, giving this first consideration, then carefully weighing all other requirements, is not going to produce a design of which there will be many repeat orders.

One type of freight car which today is undergoing the greatest transition and to which more than its share of attention is being given, is the tank car. Commodities formerly shipped in glass bottles or in carefully crated small containers, are today transported in tank cars.

The container car

Another special car which we feel is going to be used extensively when its advantages are appreciated is the container car. Where a manufacturer has consignments to several customers, none of which equal a carload, but which, on the other hand, are shipments equivalent to one-sixth or one-fourth of carload, will have delivered to his factory containers in which he can (for instance, if he is a shoe manufacturer) pack his product in the ordinary individual pasteboard boxes without the expense of cartons or packing boxes now used in l. c. l. shipments. He will fill this container with shoes in the same boxes in which they will appear on the retail shelf, seal this container, have it taken to the freight yard, loaded on a specially prepared car and transported to destination. There the container is lifted bodily from the car and trucked to the customer's receiving platform and unloaded, the container being returned to the car and sent back for the next shipment. In this manner material necessary for manufacturing crates, which, after they are once used, are generally destroyed, is eliminated, together with a marked reduction in the handling of the goods and a big reduction in the possibility of damage to the goods. This scheme of transportation is in its infancy, but indications are that its advantages are being appreciated and we can look in the near future for a marked increase in container car shipments.

In the chlorine industry there are a number of cars designed to carry 15 steel cylinders, each of which holds one ton of liquid chlorine. These cylinders can be removed, empty cylinders placed back, and the car returned for reloading.

The reduction of dead weight is a problem that is being given serious attention. As one instance, note the one-wear steel wheel. Considerable study is also being given to the use of alloys with the hope of utilizing metals of higher strength, and thus effect a saving in dead weight.

As stated, the privately owned automobile and the bus have made great inroads in passenger traffic, especially over moderately short hauls. In congested districts, of course, there is no room for the automobile to handle the masses, with the result that we have highly specialized elevated and subway systems. The study and design of this type equipment is a job in itself.

Serving the largely populated centers we have commutation trains, again a specialized traffic. Large numbers must be carried quickly and the service absolutely must maintain schedules irrespective of weather conditions. The periods of dense traffic in this service extend over only a few hours of the day, one way in the morning, the other way in the evening. However, reasonable service must be given during the balance of the day. Cars for this service must be comfortable, of large capacity and be of as light weight as possible consistent with safety.

Suburban passenger cars

Many suburban car designs have been developed, some of which adhere closely to the road's coaches for through service; others are highly specialized, some incorporating large or numerous doors to permit quick loading and unloading. One road serving Chicago is building a number of cars incorporating a large amount of aluminum, thus effecting a marked reduction in weight. Another road also has in experimental service on one of its lines entering Philadelphia cars utilizing aluminum and its alloys to quite a marked degree. It is a little early to pass on the extent to which aluminum can be successfully utilized in passenger train cars.

Remote branch line service has been hardest hit by the automotive vehicle. The truck is here the freight competitor, while the bus and privately owned automobile have made great inroads in the passenger travel. It is still necessary, however, that the roads operate these branch lines, and, as a result, we have the self-propelled car development as an answer to this problem. Here again the designer is called upon for highly specialized product. Extreme care must be given to the question of weight, and the designer who does not carefully analyze every detail which goes to make up the structure of his car, is either going to have one too heavy to be economically operated or else a structure which will have weak parts and will fail during service.

Passenger coaches too heavy

The main line passenger car for through service has been influenced less than any other by the automotive vehicle. The designer of this type of equipment, however, must give mort consideration to attractiveness and comfort than in the past. Passenger coaches of today are entirely too heavy and cannot be operated as economically as they should be. True, first consideration should be given to safety. Even safety, though, can sometimes blind one to the proper evaluating of the elements entering into the design. The usual construction of a main line coach of today is built around a heavy built-up center sill member known as fish-belly or shad-belly sill, which is in reality like a backbone to the car. This is a perpetuation of the construction used in earlier stages of development, when steel underframes were placed under wooden bodies. At that time it was necessary that the steel underframes have sufficient strength and rigidity to carry the car body and the liveload, as well as resist the buffing and pulling stresses.

When the use of steel was extended from the underframe to include the entire structure of the car, most designers still retained the heavy center sills. In the earlier designs of the all-steel car, the load-carrying members were the center sills, assisted by that portion of the side frame from the belt rail down to the side sill, while the buffing shocks were resisted by the center sills only. The superstructure of the car above the belt rail was considered as so much dead weight. When the posts were light rolled sections with little rigidity, this analysis was partially true. However, with the development of pressed posts and especially the use of box section posts the side frame becomes not a girder, whose depth is that of the belt rail down to the side sill, but the entire framework of the car is something after the fashion of a tub and it is logical to consider that the steel roof sheets, purlines, deck, side plate and letterboard all form the load-carrying member of the car and that they also, in a limited way, contribute to its shock-resisting strength at the time of a collision.

Does unlimited end strength promote safety?

For easy computation quite a few designers consider the side frame of the car; that is, side plate, letterboard, the belt rail, side sheathing, and the side sill as the carrying member of the

car. Here you have a girder between 7 and 8 ft. in depth, which has in itself ample strength and rigidity to carry all the vertical loads to which the structure will be subjected, and yet not exceed in weight, size or thickness that which it is necessary and logical to use to perform its primary function of protecting against the elements and form a support for the car roof.

A great deal of stress has been placed on making the end of the car so strong that in case of collision the car will not be penetrated. The writer believes that if the end is made too strong the shock from the impact will be such as to throw passengers around in a way to cause more damage than if the car end was not so rigid, but was symmetrically attached so that in case of a collision the vestibule will fold up or crumble and absorb, to a large degree, the force of impact due to collision and cushion the blow. While the car itself may be damaged a little bit more, passengers will be much better protected, which, of course, is the first duty of the car structure.

I have tried to point out a few of the aspects of car design encountered every day. These are additional to the purely engineering computations necessary to determine strength of individual members. We, as builders, of course, see the question of design from a different angle than you who operate and maintain the cars during service. In many ways our problems are the same. The structure which lends itself most readily to ease of maintenance is generally a construction which is easy and economical to build. Because of the necessity of maintaining existing standards, thus keeping to a minimum the repair parts necessary to carry, it is not always economical to utilize the best construction. This is a feature of which the railroad engineer should be the best judge. However, simplicity of design, as few parts as possible, and reduction of weight consistent with serviceability should always be carefully weighed against savings that can be effected by maintaining existing details. Often it is wise to cut loose from existing details and establish new designs.

The question of excessive dead weight is, in the writer's estimation, a vital one and one that should be attacked from every angle, from scrutinizing the size of the smallest detail up to the use of special materials, keeping in mind that every excess pound in the weight of the car will be ton-miles of dead load carried before the car has served its day.

Maintaining a fleet of motor coaches*

Mechanical department should have available trained mechanics and adequate facilities to properly repair buses

By F. J. Swentzel

Mechanical superintendent, New England Transportation Co.

F. J. Swentzel

Our company, which was organized in Massachusetts on June 15, 1925, and which started operations August 10, 1925, anticipates for the year ending December 31, 1927, operating about six million motor coach miles, carrying about four million people at a cost of about 29 cents per coach mile, which would include all costs.

This mileage will be run off on 43 routes, including six summer routes and will involve over 190 motor coaches, 13 automobiles and 4 trucks—total number of units, 207.

Of the 190 motor coaches, 74 are the four-cylinder type and 116 are the six-cylinder type; 50 are semi de luxe cars and 140 de luxe cars:

The four-cylinder coaches are used for handling the shorter local traffic and the six-cylinder parlor cars are used for the longer haul routes. A considerable percentage of our service is run in place of or auxiliary to the New Haven steam railroad service and this service in itself effects a considerable saving to the New Haven railroad in lieu of steam service and in itself justifies the operation. In addition to this saving, we are in position, we hope, to earn a net this year independent of the above.

In addition to the regular operation of the schedule which we cover, we in our own territory reach out for and are getting considerable so-called "party business" covering movement of special parties to and from cities within our steam railroad limits. This business is attractive as it has a tendency to utilize our surplus equipment, which is necessary for us to have to cover peak load days on Saturdays, Sundays and holidays and which can well be utilized for special party business on the first five days of the week. Our present tariff covering this service is 50 cents per mile for revenue mileage and 30 cents for necessary deadhead mileage with four hours free turnaround time after which we receive $4.00 an hour for waiting; the minimum charge for special party service is $30.00.

Our chartered coach miles in 1926 were about 92,000 miles and we anticipate doubling this mileage in 1927.

While the steam railroads and the trolleys have a function of their own, there is in and around New England a very large percentage of local travel, for one reason or another, who desire motor coach service and patronize it freely, thereby creating a very fertile field for this class of service on the highway and with particular reference to service between cities and towns approximately 50 miles apart.

There is also a considerable demand for the so-called special party business in and around New England covering seashore resorts and the mountains during the summer. This is particularly true in metropolitan Boston, which area includes a 50-mile radius and which has a population of approximately two million people.

We believe the service is one of public necessity and that it will increase, as in many cases it provides the only service which some of the smaller towns have. Railroad stations and trolley service are frequently some miles distant from the town activities. This highway service has a tendency, in our opinion, to build up rural communities and also has a tendency to create both additional and better highways.

The number of motor vehicles on the highways has increased very rapidly during the last 25 years until this business is one of the biggest in the country today involving approximately twenty-five billions of dollars if the highway improvements are included. It seems to me that this speaks for itself so far as the effect of motor coach operation is concerned.

The problems of maintenance

As with the steam railroad, the earning power of a transportation company depends largely upon the efficiency of its power. There is nothing, in our opinion, that will reduce the net income quicker than poor or deferred maintenance. In taking up the maintenance problems of a fleet of motor coaches or trucks, I wish to call your attention to a very important factor which will have a great bearing on a successful and economical operation.

Make a very careful and thorough study of the physical characteristics of the territory through which the routes are to be operated, so that you will be able to select the coach or truck equipment best suited for your operation. This can very easily be accomplished with the information you can secure from the carriers now operating coaches and through unbiased engineering

*An abstract of a paper read during the convention of the Mechanical Division of the A. R. A., held at Montreal, June 7 to 10, 1927.

advice, which is possible to secure; consequently, careful consideration should be given to the selection of your equipment, for your success will greatly depend on this. No amount of good management or skillful maintenance can result in unqualified success if your equipment is unsuitable or poor.

Before your actual operations begin, you should organize and equip a mechanical facility for the purpose of maintaining your fleet from the beginning. Do not allow yourselves to go into deferred maintenance, as you all know it is very expensive and requires a great amount of unnecessary work to put the equipment back in good mechanical condition.

Regardless of the physical conditions of the operation, I do not think it necessary to purchase more than two different types of coaches. With trucks, one make with a range of capacity from 1½ tons to 5 tons with trailers of 10 tons' capacity for terminal transfer jobs.

The purpose of calling your attention to the advisability of standardizing on the least possible makes of units, is for two reasons: first, the difficulty of being able to stock parts economically. The more makes and motors you have, the greater the difficulty in this respect. Second, the modern motor coach is less than four years old and mechanical improvements, which are being developed by the different manufacturers, are at a very rapid rate, so much so that it is almost impossible to keep up with them. For instance, a comparison of the first ten

The Providence garage is equipped with four electrically operated screw hoists

coaches delivered to us a year ago last December and the last ten, with a period of only ten months having elapsed between these delivery dates, would cause you to doubt that they had been manufactured by the same company.

Where an operating company is compelled to route its coaches through two or more states, it is confronted with a very serious problem in endeavoring to comply with the large and varied number of laws enacted, covering the public utilities and motor vehicle commissions; therefore, it is more than advisable to secure the services of an expert and qualified automotive man to inspect the chassis and body construction as they are being built, so that they will meet your specifications and the requirements of the different state laws when they are delivered to you. Up to very recently we did not have one piece of equipment delivered to us, which we could place in service, without a great number of changes and improvements being made by us.

A very important fact in economical maintenance is the protection of your equipment from abuse and mishandling by the coach operators. To best overcome this, a prospective operator should be turned over to the mechanical department by the operating superintendents, after he is qualified for employment, with a view of ascertaining if the applicant is able to judge speed and distance well enough to operate a motor coach or truck safely (the handling of both are very similar). After he proves to us that he is capable in this respect, he is placed in school under a capable mechanical instructor, not with the idea of making a mechanic out of him, but to acquaint him with the general construction of a unit, what damage is done by improper handling and how to make minor road repairs, such as locating a defective spark plug, bad electrical contact and the replacement of burnt-out electric bulbs. If the operators are able to take care of these minor troubles, it saves a great many unnecessary trips with the service cars.

It is quite difficult to secure all round automotive mechanics, as men of this type are few and far between. Another feature in connection with transportation which has a tendency to interfere with securing mechanical help, is the fact that it is a seven-day job. In the organization of our shops in Providence, I endeavored to eliminate the all round mechanic by employing men who have specialized in one particular branch of the industry. This has worked out very satisfactorily in every way and I strongly recommend an organization of this kind.

Organization of the Providence garage

As to the shop organization at Providence, I have laid it out covering two departments, or I might say two different classes of work. The back shop men, who work six nine-hour days a week and cover the machine, body, paint, blacksmith and welding jobs and the other men, whose duties are general servicing and running repairs, who work nine hours a day seven days a week covering 24 hours a day. This layout also has a tendency to facilitate the work in the auditing department pertaining to labor classification and the difference between running repairs and servicing and major and general overhauling.

The complete personnel of the main shops at Providence consist of one chief clerk, one secretary clerk and two stenographer-clerks in the superintendent's office. In the shop proper are:

1 general foreman	1 blacksmith
3 assistant foremen	3 firemen
16 first class mechanics	2 machinists
7 second class mechanics	4 helpers
4 painters	2 greasers
3 body workers	2 electricians
1 welder	2 inspectors
1 chauffeur	3 washers

This gives a total personnel of 58, with a storekeeper and three clerks in the stores looking after that department.

The machine tool equipment is complete in every detail. We can machine any part of a motor vehicle; we regrind our cylinder blocks, crank shafts, cam shafts, pistons and piston rings. Our electrical department takes care of all our generator, starter, magneto and battery repairs as well as battery charging. We make all body repairs, both metal and wood, handling blacksmithing in all its branches, except spring repairing; our spring breakage is so small that it would not be economical to operate our own spring shop. The paint shop has a capacity of three jobs in eight days. These shops take care of approximately 143 coaches, including major overhaul and servicing.

We are painting our coaches by hand, using a maroon shade of enamel. It requires more time to paint by hand, but we are convinced that it is the most satisfactory way of applying enamel.

Question of standardization

We have drawn up our own body specifications, covering both de luxe and semi de luxe types of body, embodying the features best suited for our particular operations and covering in every detail the requirements of the public utility and motor vehicle commissions in the states in which we operate. This also gives us one more standardization, something that is very desirable for a number of reasons, the most important of which is a more economical maintenance.

We have also a set of specifications covering the chassis and compel the manufacturer to comply with them, except where it might have a tendency to interfere with the general design of his unit.

Another problem, which confronted us in our operation, was brakes. We were continuously involved in any number of arguments with the state authorities over the lack of efficient brakes. There was also the danger to lives and property, which we were anxious to eliminate. After considerable experiments, we replaced defective brakes with the installation of Westinghouse air equipment and eventually will use a metal to metal brake. Other than a few minor troubles, and these we have remedied, we are satisfied that it is the proper brake equipment for both coaches and heavy duty trucks.

We have had developed by the Corbin Company a speedometer head without the odometer mechanism, which gave the company more space in the head to perfect an accurate speed indicating instrument. This instrument has two hands on the dial, one of which shows the actual speed being maintained and returns to zero when the coach is not in motion; the other remains at the point of maximum speed attained. These are checked at the terminals at the end of each trip. If it shows a speed of more than 30 miles per hour had been reached, it is reported with the operator's name to his superintendent, who in turn takes what action he deems necessary for disciplinary purposes. Our speed rule makes it a punishable offense if he exceeds 30 miles per hour. The head of this instrument is locked and requires the use of a key to reset the maximum speed hand back to zero.

These instruments are also sealed, and between the lock and seals, it is impossible for anyone to reset them without the use of a key and plunger.

System of inspection

We have at all large terminals mechanical department employees, whose duty it is to inspect all arriving coaches, covering motor, motor oil level, tires, steering gear, brakes, lights and body damages. We also inspect every coach nightly after it has been turned over to us by the operating department. This inspection covers all parts, which should they fail to function properly, would cause a road failure or accident, general condition of the motor, bodies, lights, oil level and includes checking up for oil change and greasing mileage. The value of both the terminal and nightly inspections is best shown by our records for the Saturdays, Sundays and Mondays of Memorial, Independence and Labor days of last year. We went through these nine days of peak load holidays without a mechanical road failure. We have had a few accidents caused from defective parts, not detectable by inspection, but we have not had one which could be caught by inspection.

The manufacturers of motor coaches need educating in what is best suited for a safe and economical operation, and I am more than confident that the carriers with the assistance of their automotive engineers are best qualified to do this. To give you an idea of what I mean, I might take up the filling of coaches with gasoline. Our coaches all have tanks of 50 gal. capacity and the filler pipes are so small in diameter that it takes from five to twelve minutes to fill the tanks. This causes overflow waste of gasoline on the ground and it also interferes greatly with the maintenance of our schedules.

Maintaining a fleet of motor vehicles is quite a problem when they put up at your own garages, but it develops into a much greater problem when your fleet is scattered from Provincetown on Cape Cod to the eastern boundary of New York State, relying on another subsidiary of the New Haven at four points, 25 public garages and shops at other tie-up points, with our own eight shops to service and keep in repair our fleet. This requires a great deal of mechanical supervision that would not otherwise be required.

Mileage of buses for lubrication and repairs

There is a great difference of opinion in regard to the proper greasing of the chassis and renewal of crank-case oil. We have given these conditions very careful study and after thorough tests we adopted the following: We grease universal joints and steering gear parts at 500 miles; the complete chassis at 1,000 miles; a complete crank-case oil change at 1,500 miles.

There are at least two practical oil filters on the market for unit installation that are not only practical but will, I am sure, triple our present oil mileage when we are in a position to install them. I have made a careful study of oil reclaiming operations and I am convinced that nothing is to be gained by using them in their present stage of development.

Another question which comes up from time to time is what mileage period should a coach or truck be given its major overhaul and when should maintenance cease and replacement take place. In the first place, it is impossible positively to fix the replacement period, for replacement of parts takes place in a great majority of cases before the unit has covered any great mileage. The proper general overhaul, including replacement, can only be governed by the physical characteristics of your operation and the service required of the units and if they are being furnished with the proper grade of oil and lubrication.

I am sure that 85,000 miles, under normal conditions, is about the proper period that may be figured on for the first major overhaul. This major overhaul, including the reboring of blocks, with, of course, oversize pistons and rings to fit; replacement of bearings in some particular makes of units and in some cases new timing gears, the regrinding of crank-shafts and the refacing of valve seats and general overhauling of the electrical equipment, with, in most cases, replacement of parts.

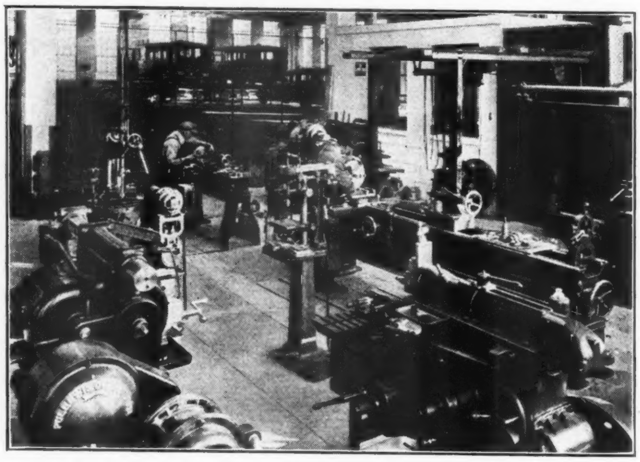
If a coach which has been shifted to an isolated point has had a major overhaul, or in other words had work done on it, which takes it away from the manufacturer's standardization and that coach breaks a piston or burns out a bearing and we at Providence are called upon to furnish this part, we must be in a position to send them a part that may be fitted with the least amount of labor; consequently, it requires us to keep a complete record in my office of what work has been done on every job, covering the size of rebore of cylinders, the regrinding of crank-shafts, the out of place alinement of the crank-shaft, to take care of the replacement of timing gears, etc.

I wish to take up a very important factor in connection with successful motor maintenance and that is, proper grade of oil to be used. It is impossible for an operating company on the Atlantic Seaboard to recommend the proper grade of oil to a company operating the same make of units in another territory; this you must work out for yourselves. We have coaches of the same make and model operating in two territories under different conditions and remote from each other, and we secure better results by using two different grades of oil.

I have had the question put up to me as to which was the best grade of gasoline. This is also a question that will be necessary for you to work out yourselves. One make of gasoline will give better results in the same make of vehicle in one territory than in another and work out just the opposite in a different type of vehicle.

Owing to the great area covered by our operation, and owing to the fact that we are tying up at a great number of isolated points, it was necessary to develop a system of records and reports so that we could check up on the companies at these isolated points doing mechanical work and servicing for us; this we have accomplished, I am more than confident, for it is impossible for a unit to go over its greasing or oil change period more than 24 hours before we catch it. If a unit goes by these periods and does not show up on the daily report, we get in telephonic communication with the company involved informing them of the fact and follow it up with a call from a member of the mechanical supervision to see that our instructions are complied with.

Our whole operation in regard to tires is being run on a guaranteed mileage basis, the contracts being signed with the



The machine shop of the Providence garage

Fisk Rubber Company covering the Rhode Island and Massachusetts divisions and the United States Rubber Company covering the Connecticut division. I am not qualified to give you the figures on our tire mileage, especially at this time, for the mechanical department does not handle these figures, and for another reason, we have not done the mileage where the figures would be of advantage to you, but from my personal observation, I feel sure that regardless of the fact that motor coaches are undertired, you should get from 18,000 to 26,000 miles out of your tires.

The back shops of The New England Transportation Company at Providence will take care of the major overhauling of the internal combustion engines of the gas rail-car equipment of the New Haven Railroad system.

[In presenting the paper, Mr. Swentzel added the following material not included in the formal paper. Editor.]

It was necessary, not only from a maintenance standpoint but from an operating one as well, to group our different fleets; in so doing we were able more economically to stock substores not only at our shops other than Providence, R. I., but also at remote points where we must rely on public shops. This system also makes it possible to train our mechanics, handling equipment on certain routes, on one particular make of unit and has a tendency to eliminate a great deal of abuse of equipment by operators. Where this is done we have noticed a decided decrease in repairs, caused by mishandling. We were somewhat handicapped for the fact that our patrons on one route insisted on a certain type of unit, while on others they wanted an entirely different type.

In the operation of motor coaches, the assignment of equipment should be the proper one from the beginning; do not begin an operation with a six-cylinder coach if a four-cylinder will handle it. Educate the public to a six-cylinder unit and you will have great difficulty in satisfying them with a four-cylinder. It is generally believed that you can operate a four-cylinder coach more economically than a six-cylinder one. This is a fact

if the route is suited for a four-cylinder unit, but if not, a six-cylinder unit will perform more satisfactorily.

We have now reached the point where the present mechanical personnel in the back shop at Providence may be retained intact all the year round; a condition that is very desirous, as we have at all times the same well trained force, which means efficiency and economical operation, and above all, the employees are contented and satisfied.

We devote a great deal of time and study to necessary experiments in trying to rectify the chronic troubles we have with our units. I assign certain employees to make a thorough study of the troubles we are experimenting with each make of unit, with a view of working out, in our own way, ways and means to remedy them. I do not ignore the recommendations of the manufacturer by any means, but I do make a thorough study of the operation of each make and use their recommendations as a basis for our experiments. The manufacturers do try to help us in every way possible and I would like to see their engineering departments keep in closer touch with the mechanical departments of the large operating companies.

I have been asked on numerous occasions since my visit to Montreal if the railway mechanics adapt themselves to work on internal combustion engines. We tried it out. I know several other roads did, and we had no success. The automotive trained mechanic is a man who lacks the discipline that the railroad mechanic has in his training, but the railroad mechanic is used to rougher work and has more leeway, for instance, in the fitting of bearings than the automotive mechanic. Consequently, it is a great deal more satisfactory to take men who have had a little automotive training and train them than it is to take the railroad mechanic and try to make an automotive mechanic out of him. Five railroads have had the same experience. The mechanical personnel of the New England Transportation Company is 100 per cent automotive mechanics.

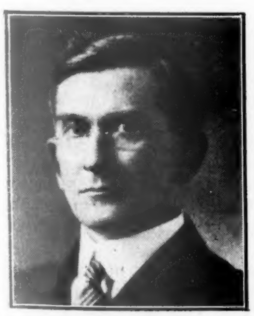
Electric power in steam railroad service

Developments in electric rolling stock and lighting equipment discussed at Montreal

THE rapid development in electric power and its more extended utilization by the steam railroads throughout the country has resulted in the creation of many problems for mechanical department officers. These problems have to do with the application of electric lighting equipment to locomotives and passenger cars, the use of electric power in repair shops, and the maintenance and some phases of the design of electric locomotives on roads using heavy electric traction.

The reports on electrical rolling stock and on locomotive and train lighting which were presented this year at the annual meeting of the Mechanical Division, A. R. A., at Montreal, Que., June 7 to 10, inclusive, contain considerable information of value not only to electrical officers, but to mechanical officers as well. Both reports, abstracts of which are published in this article, deal largely with problems of maintenance. In addition, the report on electric rolling stock goes into the subject of lateral forces acting upon a locomotive when passing through curves and also contains a review of developments during the past year.

Report on electric rolling stock



L. K. Sillcox
Chairman

The 1927 report of the committee on electric rolling stock is usually comprehensive and embraces a variety of subjects. It is presented herewith in outline, special attention being given to information concerning operating results of existing electrified roads.

Lateral forces acting upon a locomotive when passing through a curve

During the past year, the committee has conducted its studies in regard to the height of the center of gravity of electric locomotives and of variable resistance trucks. A large amount of data has been assembled pertaining to both subjects but only that concerning variable resistance trucks has been prepared for report. The data relative to the subject of variable resistance trucks appear in the form of an instructive and thoroughly prepared paper presented by A. Kearney, superintendent motive power, Norfolk & Western. The paper is highly technical and the conclusions are based on a general analysis of especial interest. They are as follows:

1—When a locomotive is running without exerting tractive effort, except for its own movement, the lateral resistance in the leading truck should be relatively large and the lateral resistance in the trailing truck should be zero.

2—Since the primary object of the locomotive is to haul cars, and the physical characteristics of the roadway vary between certain rather definite limitations, the locomotive design might best be a good compromise for the variation in operating conditions, consideration being given to the effect upon lateral forces for the various conditions of draw-bar pull encountered.

3—An analytical study is of value towards interpreting the results of experimental study and observation, and in estimating, in a general way, the results that might be expected from certain features in design.

4—A satisfactory locomotive would seem to be one which will traverse curves with freedom and without cramping or localizing stresses, and without excessive wear and punishment to detail parts of track and machinery.

5—Rail and flange wear are factors by which some of the qualities of a locomotive design might be judged and that rail and flange wear are closely related to track stresses, although it does not seem possible to definitely measure the varying track stresses and yielding of track, and therefore to calculate with a degree of certainty the amount of rail and flange wear.

6—A high lateral resistance is desirable in the front truck and a low lateral resistance in the trailing truck. Although, when the locomotive is called upon to do practically as much work in one direction as in the other, an ideal condition might be obtained by reversing or exchanging the characteristics of the leading and trailing trucks.

7—Those associated with the operation of electric locomotives, which are run practically as much in one direction as in the other, might with profit observe the rate of flange wear, tire and rail wear and all the factors which might have contributed to unsought conditions and from which observations more accurate determination might be made for the most economical apportionment of wear between the various elements for the peculiar or local conditions.

In the appendix, brief reference is made to some practices in locomotive design as well as to some features of design which have been proposed in connection with the lateral resistance of leading and trailing trucks on heavy electric locomotives.

After analyzing the situation, the committee has reached the conclusion that the figures as reported to the Interstate Commerce Commission are not adaptable to the purpose of comparison of operating data on electric rolling stock between various roads, although suitable for the purpose for which it is in-

tended. The report further states that it is desirable to have the electric locomotive ratings included in the data annually collected by this committee and included in their report, prepared on the same basis for each road if possible; and it is therefore the recommendation of the committee that this subject be given further consideration next year, with a view to establishing a standard method of reporting electric locomotive ratings for the A. R. A. report.

Standard system of nomenclature for electric locomotives

The point of special interest in the report of the sub-committee on nomenclature is that the "Standard" system of nomenclature for axle and truck arrangement of electric locomotives be adopted. This recommendation is made in accordance with practice of American manufacturers and is used by the manufacturers because the Whyte system has limits with regard to electric locomotives which makes its use undesirable. There are electric locomotive wheel arrangements which cannot be designated by the Whyte system. A locomotive which has a wheel arrangement 2-6-2+2-6-2+2-6-2 according to the Whyte system is designated as 3 (1-C-1) by the Standard system. The Standard system was described in detail in an article published in the February 27, 1926, issue of the Railway Age.

Detroit, Toledo & Ironton electrification

The section of the report devoted to the D. T. & I. was prepared by F. L. Rockelman, vice president and general manager. The power supply, catenary system and motor generator type locomotives are described. The electrification includes 17 miles of double track line between Fordson and Flat Rock, Mich. On the basis of a year of successful operation, Mr. Rockelman makes the following comments:

"The two motive power units working as independent units completed a total of over 70,000 miles in service during the first year's operation and have had an availability factor of virtually 100 percent.

"A single unit has handled a maximum train of 137 cars with an estimated tonnage of over 6,000 tons.

"One of the interesting features of this operation is the maintenance procedure followed. A special maintenance force has not been built up and the regular locomotive operators, consisting of engineers and helpers, are used to maintain the locomotives they run. This procedure has been made possible due to the small amount of maintenance actually required. Also, another interesting development has been the relatively large amount of time the operators avail themselves of the regenerative feature of the locomotive to slow down trains.

"During the trip between Fordson and Flat Rock three other main line railroads are crossed, i. e. the Michigan Central, Wabash and the Pennsylvania, and practically every trip it is necessary either to stop or slow down at one or more of these crossings.

"During steam operation prior to the electrification it was customary to use air on the train in the majority of such cases with loss in time.

"Since the electric units have been put in service nearly all slow downs or stops are made with regenerative braking. Hence, if a clear signal is given just as or just before the train has stopped, the train can be immediately accelerated without any loss of time.

"The flexible control provided by the locomotive has enabled the trains to be handled with practically no injury to the equipment whatever and not a single drawbar has been charged against the electric locomotives since the service was inaugurated.

"Plans are under way for additional locomotives and extension of the electrification."

Virginian electrification

Last year's report of the committee included a paper by J. W. Sasser, superintendent motive power, Virginian, which dealt with the various phases of the Virginian electrification. In this report, Mr. Sasser supplements the information presented a year ago. This additional information is brief but of particular value because of the operating data it contains and with the exception of three power plant load curves, is published herewith complete as follows:

In last year's report on the Virginian electrification, a general description was given and operation of the Mullens-Princeton section was described. Since that time, the remaining section extending to Roanoke, Va., has been completed and operation inaugurated the middle of September, 1926. As indicated in last year's report, trains were made up to 9,000 tons at Clarks Gap, and handled to Princeton by one locomotive. On September 18, 1926, the first train left Clarks Gap for Roanoke with full tonnage of 9,000 tons, returning west the same day, with a train of approximately 2,800 tons of empties. Operation through to Roanoke has proved successful, regeneration being taken care of to the full capacity of the locomotive. In the run of 118 miles from Clarks Gap to Roanoke, the 9,000-ton trains are handled at the 28-mile-an-hour speed for approximately 45 miles, and at 14 miles per hour for the remainder of the run. There is only one regular stop, arranged for the inspection of trains, at Whitethorne, and runs are frequently made with only this one stop.

In operation through to Roanoke with electric power, the practice of making up eastward trains at Princeton, and the pusher service maintained under steam operation at Whitethorne, have been discontinued, with considerable saving in time and expense. Westward trains of empties are stopped at Princeton for inspection, the electric locomotive leaving its train at this point, picking up the previous train inspected and proceeding to Elmore.

Since operation through to Roanoke has obtained, the Virginian experienced in the months of October and November, 1926, the heaviest business in its existence. During the month of October, 211,420,600 gross ton miles represented the work done by electric locomotives, while in November, the figure reached 213,545,860. The average locomotive mileage per day for 3-cab locomotives for the month of October was 139.1, and for November, 147.6. In considering this figure of average locomotive mileage per day, the fact should not be lost sight of that more than 50 per cent of the locomotives were used on short runs and hill service, including pusher service, and that all the locomotives owned were considered in the above average mileage, whether in service or in terminals for any reason. Individual locomotives operating in the 135 mile run between Mullens and Roanoke greatly exceeded the above average mileage, the daily mileage frequently being in the neighborhood of 270 miles. The locomotives have stood up remarkably well in service. One maintenance feature of particular general interest is the success of the floating bushings applied to the main and side rods. Up to the end of December, 1926, only one floating bushing was removed; and judging from results already obtained, it does not appear improbable that an average life of 60,000 miles will be obtained from these bushings.

Locomotive maintenance costs are often figured in cost per locomotive mile, but a comparison of this nature is of little value unless similar locomotives operating over an identical profile are being compared. Furthermore, the number of units per locomotive varies. However, following this system, the cost of electric locomotive repairs is 9.8 cents per unit mile for October and November, 1926, and 13.6 cents per unit mile from January 1 to November 30, 1926. When prorated to 100 tons on locomotive drivers these figures become 6.4 cents and 8.8 cents, respectively. Even this, however, is not a satisfactory basis for comparing locomotive maintenance costs, and some other measure should be employed to indicate the cost on the basis of work done by the locomotive. In the case of the Virginian locomotives, which are equipped with watt hour meters, this can readily be ascertained by taking the total energy in kilowatt hours used by the locomotives both for motoring and regenerating, which is a very close measure of the work done, and dividing this into the total repair cost. The cost so obtained is 1.3 mills per kw.-hr. used. for the months of October and November, 1926, and 1.27 mills per kw.-hr. used from January 1 to November 30, 1926. The cost of electric locomotive repairs of other roads on this basis is not now readily available for comparison, but it is hoped that the practice of keeping the record in this way will be encouraged.

Brief reference has been made in the previous report to the Narrows Power Plant; practically all that remains to be said is that experience has justified the used of pulverized fuel as being well suited for handling the sudden load changes inherent to Virginian Railway traffic conditions. Until the electrification was completed and the power plant operated under the load conditions for which it was designed, the coal consumption was unavoidably high, but for the months of October and November, it averaged 1.66 lb. per kw.-hr. During this period the load factor was 52 percent, with an average power factor of 85 percent, based on the total output of the generators obtained from the actual hours run during this period compared with their rated capacity.

The cost of producing power, including fuel, operation of power plant, and maintenance of power plant, substations, transmission line, distribution system and track bonding, for the ten months ending October 31, 1926. was 4.388 mills per kw.-hr. produced at the power plant. During October and November, when the increased and better load, due to operation through to Roanoke, was experienced, the cost per kw.-hr. was 3.401 mills and 3.787 mills, respectively.

During the month of November, 1926, the maximum output

was reached, figures of some interest being shown in the following table:

Energy generated, total for month	11,212,000 kw.-hr.
Energy generated, net for month	10,719,100 kw.-hr.
Energy generated, total maximum day	441,000 kw.-hr.
Energy generated, net maximum day	423,600 kw.-hr.
Maximum: Instantaneous load for month (3 generators on line)	47,000 kw.-hr.
Maximum: 5-minute load for month (3 generators on line)	42,000 kw.-hr.
Maximum hour load for month (3 generators on line)	31,000 kw.-hr.

An interesting feature of the power supply is that supplied by the locomotives themselves, through regeneration as referred to in the previous report. During the two months under consideration, it was demonstrated that practically all of regenerated power is being absorbed by other locomotives, the water rheostats at Narrows power plant very seldom coming into operation. This is a real factor in operation, as 8.3 percent of the total power consumed by electric locomotives while motoring during this period was supplied by regeneration.

An inspection shed has been installed at Roanoke, Va., to take care of inspection and minor repairs, lubrication, etc., the locomotive being prepared for the return trip in a minimum time, averaging two hours. All ordinary maintenance and heavy repairs are made at Mullens and fifteen months of operation have demonstrated that the shop facilities specially provided for electric locomotives at that point have justified the design and capital outlay.

The transmission, distribution, and catenary systems were described in the previous report, and nothing much can be added to that statement, other than that no serious defects have developed and the general arrangement has been found to meet the requirements of operation.

As stated above, the business handled by the Virginian during 1926 exceeded all previous experience, and, during the two months mentioned, placed upon the electrification a demand closely approximating, if not exceeding, the traffic on which the number of locomotives provided was based. The Virginian feels, from results obtained, that electrification through its mountain division has proved a success and has justified the capital outlay.

Illinois Central electrification

During the year covered by this report, the Illinois Central has inaugurated electrical service on its suburban lines in Chicago. This project is notable in the high motor capacity provided per unit of train weight in order to permit high rates of acceleration. There are many other interesting features involved and to make these available to members of the association, the committee invited E. W. Jansen, electrical engineer, Illinois Central, to prepare a paper covering this most recent project. The report by Mr. Jansen includes the history leading up to the electrification, some operating results and brief descriptions of the supply system; the supervisory remote control; a.c. light and power service; inspection and repair shops; heavy inspection shop; multiple unit cars; motors, control, and auxiliary equipment; instructions for train employees. That part of the report which deals with operation results is included in the following:

In 1922 a commission was appointed to make a study of the type of system best suited for the Illinois Central suburban electrification, four different voltages being considered, with the result that a 1,500 volt, direct current system, with overhead catenary system of construction to deliver current to the cars and locomotives was decided on, on the basis that it was a Terminal Electrification only.

Suburban service covers the following tracks on the main line south:

Randolph street to Eleventh street, 1.3 miles, two main tracks and one equipment lead.

Eleventh street to Fifty-first street, 4.9 miles, six main tracks.

Fifty-first street to One Hundred and Fifteenth street (Kensington), 8.1 miles, four main tracks.

One Hundred and Fifteenth street to Matteson, 13.7 miles, two main tracks.

In addition there is a branch line to South Chicago consisting of 4.5 miles of double track connecting with the main line at Sixty-seventh street, and a single track branch line from Kensington (One Hundred and Fifteenth street) to Blue Island, 4.4 miles. The Chicago, South Shore and South Bend, which changed from 6,600 volts a. c. to 1,500 volts d. c. in 1926, operates hourly trains from Randolph street to Michigan City and South Bend with 30 minutes service between Randolph street and Gary, these trains connecting with the Illinois Central at Kensington. The double track portion of that line from Kensington to the Illinois-Indiana State Line, 6.5 miles, is owned by the Illinois Central and leased to the C. S. S. & S. B.

A decrease of from 10 to 24 per cent, depending on number and location of intermediate stops has been made with the electric trains as compared with former steam operation, there now being 475 scheduled trains week days, including trains of the C. S. S. & S. B., operating between Kensington and Randolph street. Train miles at present are about 214,000 per month, with about 855,000 car miles. In January, 5,442,041 traction kw.-hr. were used including C. S. S. & S. B., the maximum demand was 20,104 kw., or 6.36 kw. per car mile, including heating.

The construction of the cars began in August, 1925. The overhead catenary system was started August 3, 1925, but did not reach full headway until October 1. The first revenue trains were operated July 21, 1926, between Randolph street and Sixty-seventh street on local tracks. A formal opening of the service was made on August 7, and the complete service was placed in electric operation on September 1, 1926, or about six months in advance of the time required by the ordinance. At the present time 260 cars are in service, operating in two-car units, there being 130 motor cars and 130 trailers, a motor car and trailer being semi-permanently coupled and operating as a unit. These cars operate in local, express and special service. Local trains make stops on an average of 0.6 miles. Express trains 5.8 miles in length, followed by local runs or an average of 1.0 mile between stops. Special trains average 1.7 miles between station stops, but on some runs there is from 5.8 to 14 miles between stops.

After considerable study, an acceleration rate of 1.5 miles per hour per second, with a balancing speed of 57 miles per hour and braking rate of 1.75 miles, per hour, per second, was decided upon. In actual service a speed of 65 miles per hour is frequently attained. The motor cars are equipped with four 250 horsepower motors, giving 500 horsepower for each car in the train.

Table I—Steam and electric schedules for Matteson trains

Distance from Randolph st. to Matteson is 27.93 Miles

	Steam schedules (1925)		Electric schedule requirements			Electric schedule actually obtained		
	Intermediate stops	Schedule time in minutes	No. of intermediate stops	Schedule time in minutes	Per cent decrease in time electric vs. steam	No. of intermediate stops	Schedule time in minutes	Per cent decrease electric vs. steam
Local	34	80.0	33	72.5	9.4	*36	68.5	14.4
Express	25	79.0	25	63.5	19.6	*28	64.7	18.1
Special	14	64.5	13	53.0	17.8	*15	53.0	17.8
Golf special	9	60.0	8	46.0	23.3	8	45.7	23.8

*A short time previous to starting electric operation, the station stops were increased to the number shown.

Twenty years' electrical operation on the New York, New Haven & Hartford

This year marks the twentieth anniversary of electrical operation on the New York, New Haven & Hartford, and as a part of this report W. L. Bean, mechanical manager, New York, New Haven & Hartford, has presented a history of the experience of the New Haven with electric motive power. More electric traction history has been made on the New Haven than on any other road and in this report Mr. Bean presents this history in a form invaluable to the student of electric traction and to the prospective user. Only that part of the report which concerns operating results is included in the following:

The electric zone of the New York, New Haven & Hartford Railroad consists of the following:

Woodlawn, N. Y., to Cedar Hill, Conn.	4 tracks	63 route miles
Harlem River, N. Y., to New Rochelle, N. Y.	6 tracks	12 route miles
Oak Point, N. Y., to Fresh Pond Jct., L. I.	2 tracks	8 route miles
Stamford, Conn., to New Canaan, Conn.	1 track	8 route miles
So. Norwalk, Conn., to Danbury, Conn.	1 track	24 route miles
*West Farms, N. Y., to Mt. Vernon	4 tracks	6 route miles
*Mt. Vernon to White Plains	2 tracks	8 route miles
*Mt. Vernon to Harrison	2 tracks	6 route miles

*Operated by New York, Westchester & Boston.

Through passenger traffic is handled between Grand Central Station and New Haven, and between Sunnyside, Long Island (Pennsylvania connection to Pennsylvania Station) via the Hell Gate bridge route and New Haven.

Commuter service is handled from Grand Central Terminal to New Rochelle, Port Chester and Stamford principally by multiple unit car trains arranged to give local and express service.

The local service on the Harlem River, New Canaan and Danbury branches is also handled by multiple unit trains.

Local passenger and freight traffic and service to New York is handled on the New Canaan and Danbury branches.

The Line from Oak Point to Fresh Pond handles freight only. At Fresh Pond the electrification will continue later in 1927 to Bay Ridge over the Long Island's line. Freight trains will then be handled between Bay Ridge and Cedar Hill, Conn., a distance of 88 miles. The present electric movement of freight trains is between Oak Point and Cedar Hill, a distance of 68 miles. This route is one of the two principal western gateways for freight for the New Haven.

The New York, Westchester and Boston, a subsidiary of the New Haven, separately operated, handles commuter service between Harlem River, the Bronx, Mt. Vernon, White Plains, New Rochelle and intervening stations to Harrison. Construction to Port Chester will ensue at an early date.

Local freight service on the Westchester is handled by an electric locomotive.

Mileage performance of equipment

Forty-one passenger locomotives of the earlier type have been in service twenty years. The average for each serviceable locomotive is 170 miles a day and the total mileage per locomotive of this type has reached about a million and a quarter miles. After this remarkable mileage these engines still handle most important main line fast trains, which record as to locomotive age, mileage and character of service, is unquestionably not equaled in steam service anywhere.

The latest type of passenger locomotive, known as the 0300 class (22 of which will soon be in service and 5 on order) have averaged nearly 250 miles a day, and during the past year several of these engines have made nearly 100,000 miles. It is not unusual for one locomotive to make between 400 and 500 miles in 24 hours even though the longest run is only 73 miles. One engine made as high as 11,000 miles in one month.

Electric passenger locomotives made 377,000 miles in October, 1926, or 214 miles per serviceable locomotive per day. The average locomotive mileage per day for all serviceable freight locomotives is 150. Electric switching locomotives have records of 4,300 to 4,500 miles monthly, and are kept in service twenty-four hours a day for as many as thirty days continuously.

It is not unusual for an electric freight locomotive to make a round trip from Oak Point to Cedar Hill, 138 miles, in six hours, which makes possible two round trips per day for these engines. The freight locomotives average about 160,000,000 ton miles of freight per month at an average train speed of about 18 miles per hour. This requires around 125,000 freight-locomotive-miles per month, or 150 miles per locomotive per day, for serviceable engines. The 36 freight locomotives which were placed in service in 1912 and 1913 have now averaged nearly a half million miles for each engine, the present average yearly mileage being 46,000 miles for the total number of engines of this class owned. A maximum month recently showed nearly 6,000 miles for an engine of this type. In the same month, electric motor cars made over 126,000 miles, or 97 miles per day for all cars in service.

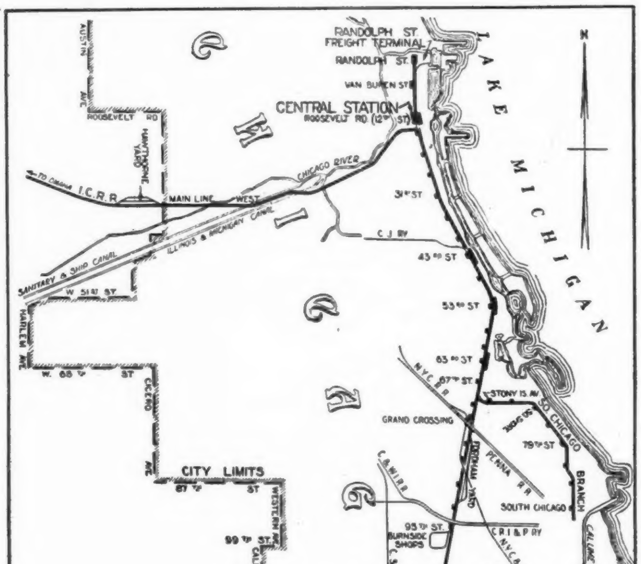
Passenger traffic handled in the electric zone

The passenger service, handled by locomotives for the express trains and local express trains and multiple-unit cars for the local commuting service, involves very dense passenger traffic. The New Haven Railroad brings to its passenger terminals in New York City approximately 28,000 passengers daily, and about one-half of this passenger traffic is handled during the two-hour rush period night and morning. In 1925, 18,000,000 people were handled into Grand Central Terminal.

The "fleet" movement of trains carrying commuters into New York from Connecticut and the nearby New York State points, increases in density approaching New York, as one suburban zone after another is entered. At Stamford, Port Chester and New Rochelle, train movements are added. Between Stamford and Mount Vernon there are fourteen stations in a distance of nineteen miles, generally located in centers of considerable population. The accumulation of passenger load and additional trains causes an extremely dense traffic reaching its peak at New Rochelle Junction. At this point, where the 6-track Harlem River branch leaves the main line, 261 trains and 3,483 cars pass during a normal 24-hour period. There have been as many as thirty trains in one hour through this junction.

The New York, Westchester & Boston Railroad, a subsidiary of the New Haven Road, handles suburban traffic between White Plains and Mamaroneck to Harlem River, where connection is made with the Interborough Rapid Transit lines. This road is now extending its line parallel to the New Haven system to Port Chester, N. Y. It takes care of a very large commuting traffic and maintains a schedule, very convenient to the suburban district, of two trains every twenty minutes in and out of New York throughout the day. The multiple-unit cars handling this service are equipped with the same single-phase motor used on the New Haven equipment.

Exclusive of the New York, Westchester & Boston, the New



Map of electrified sections, Illinois Central

Haven handles approximately 350,000 passenger locomotive miles monthly and 100,000 passenger motor car miles.

Of every thirteen passengers riding on standard railroads in this country, one rides on the New Haven, and one out of every nine passengers riding on commutation tickets also uses the New Haven.

The New Haven has the heaviest main line traffic of any electrified railroad of its length in the world.

Freight traffic

The freight service on the electric zone extends from Oak Point and Harlem River yards to the Cedar Hill classification

yard, just east of New Haven. Freight is also received from the Pennsylvania at Bay Ridge, L. I., and at present it is moved by steam locomotives to Oak Point, over the Long Island and New York Connecting Railroad. The electrification of this route is now under construction with the expectation it will be completed by July 1, 1927. The through traffic will be handled by the New Haven.

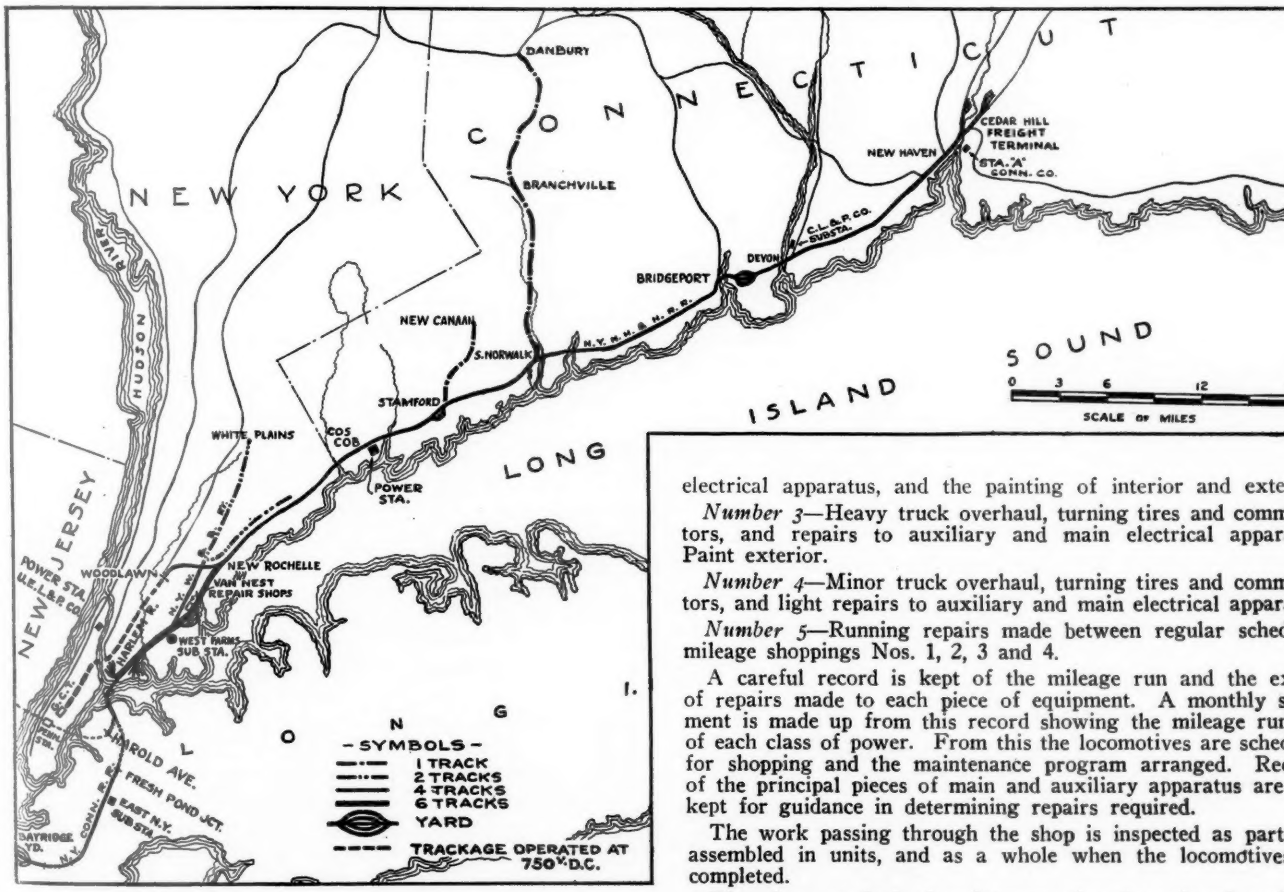
The Long Island has just received fourteen 11,000 volt locomotives which will be used in float, yard and transfer service in the Bay Ridge yards. This electrification will assist train movement through the tunnel in East New York.

The New Haven Railroad receives daily approximately 950 freight cars from its connections on the Jersey Shore and forwards some 1,100 cars per day eastward. As many as 16 trains totaling 813 loaded freight cars have been started eastward from Oak Point yards in six hours. This yard at Oak Point is the largest electrified yard in the world, having 35 track miles equipped with overhead wire. In October, 1926, 179,076,000 ton miles of freight were moved by electric locomotives with an average train speed of 17.18 miles per hour.

Switching service

Electric switching service is maintained at the Harlem River terminal yards and several other yards between those points and Stamford. The service required of these engines consists of pulling and loading floats which interchange freight with the Jersey Shore (this being extremely heavy duty under certain conditions of tide and load) as well as the classification of trains and other terminal yard work, and use as a helper engine on the 1.2 per cent grade of the Hell Gate Bridge for westbound freight trains to the Bay Ridge yard.

Three of these switching locomotives, in multiple, have been tried out in humping service in the Cedar Hill classification yard. Their performance is considered very satisfactory. The steady uniform torque of the electric locomotive is specially suitable for tipping the cars over the hump one at a time at regular intervals and at the desired speed. The 16 original switcher locomotives with single-phase motors, have been in service about 14 years and have made an average of 492,000 miles each, or a yearly average of around 37,000 miles for all engines of this type. Six more switcher locomotives similar to the original 16 are now being built and will soon be in service.



Map of alternating current electrified zone, New York, New Haven & Hartford

Inspection and repair program

The locomotives are given periodic inspection between 2,500 and 3,000 miles, the multiple unit cars between 2,000 and 2,500, while the trailers are given inspection once every three months.

All repairs are now made on a mileage basis which has been carefully worked out for each class of equipment in accord with experience gained during the last twenty years of operation. Depending on the extent of the work to be done, the repair job falls into one of the five classifications. The classifications are so arranged that a second, third or other periodic shopping registers with the time for general overhaul. For instance, on the latest class passenger locomotives this works out as follows:

Mileage	Class of repairs
At 55,000	4
At 110,000	3
At 165,000	4
At 220,000	3
At 275,000	4
At 330,000	2

The classification of repairs are:

Number 1—(a) Rebuilding locomotive or car, replacing or relocating apparatus on a major scale, involving large amount of work and expense.

(b) Extensive repairs or replacements made necessary by accident or fire.

Number 2—Periodic general overhaul of all mechanical and electrical apparatus, and the painting of interior and exterior.

Number 3—Heavy truck overhaul, turning tires and commutators, and repairs to auxiliary and main electrical apparatus. Paint exterior.

Number 4—Minor truck overhaul, turning tires and commutators, and light repairs to auxiliary and main electrical apparatus.

Number 5—Running repairs made between regular scheduled mileage shoppings Nos. 1, 2, 3 and 4.

A careful record is kept of the mileage run and the extent of repairs made to each piece of equipment. A monthly statement is made up from this record showing the mileage run out of each class of power. From this the locomotives are scheduled for shopping and the maintenance program arranged. Records of the principal pieces of main and auxiliary apparatus are also kept for guidance in determining repairs required.

The work passing through the shop is inspected as parts are assembled in units, and as a whole when the locomotives are completed.

The above method of maintenance has been found profitable because the old adage "A stitch in time saves nine," holds very true for the electric locomotive.

Conclusions

The foregoing is intended to picture briefly the high spots of the history of the New Haven electrification and to give a measure of its character and extent.

It must be considered the project undertaken in 1907 was of great magnitude, and, in view of the then state of the art, required great courage.

Those who prescribed the earlier arrangements and who overcame the relatively few, but nevertheless annoying, physical difficulties leading to the splendid accomplishment which has resulted, are entitled to the fullest recognition of their technical abilities,

their courage and their steadfastness in building what is in fact a monument to their skill and endeavors.

Is the result a success? If anyone doubts he should accept the invitation to delve into all the ramifications and complexities of the problem and especially to start by attempting to consider some other method of train propulsion (steam, most probably), which would give the same traffic capacity, reliability, safety, comfort, quietness, cleanliness and economies, all things consid- ed as are being accomplished by electrification.

Electrification progress

The committee concluded its report by outlining electrification progress made during the year both in the United States and abroad and by suggesting subjects for consideration during the coming year. The report is signed by L. K. Sillcox (chairman), Chicago, Milwaukee & St. Paul; G. C. Bishop, Long Island; W. L. Bean, New York, New Haven & Hartford; J. A. Carmody, New York Central; J. H. Davis, Baltimore & Ohio; A. Kearney, Norfolk & Western; J. V. B. Duer, Pennsylvania System; J. W. Sasser, Virginian, and E. W. Jansen, Illinois Central.

The report was accepted and the committee continued.

Report on locomotive and train lighting

W. E. Dunham
Chairman

The report on locomotive and car lighting is presented by the committee with the following comment:

"The introduction of the body suspended generator, some years ago, brought with it several important advantages as regards safety, simplicity of generator suspension, truck conditions, method or procedure of applying the axle pulley, facilities for inspection, repairs, etc.

"The committee has kept in touch with the progress of the art in this connection and has found a rather decided trend toward the mounting of the axle pulley, for body suspended generators, at the center of the axle, thereby aligning the belt with the longitudinal center line of the car. This arrangement gives increased security in the application of the pulley to the axle, better facilities for making inspection and repairs and appreciable increased belt life at little or no increase in the cost of application. The tendency appears to be strongly in the direction of a more general or widespread use of this form of application, and because of the advantages accruing, its further use should be encouraged.

Photometry of headlights

"Experiments have been conducted during the past year or two with a view to developing a more convenient and satisfactory method of photometric measurement of electric headlights to facilitate comparisons between different makes of equipment when purchases are made upon a competitive basis and to enable any railroad readily to check equipment in active service. So far the results of the experiments have not been very encouraging and the experiments are, therefore, being continued.

Axle generator specifications

"The specifications for axle generators, outlined in the manual, are in need of general revision. It was found impossible to complete this work for inclusion in this report. The revision is, however, now under way and it is expected that formal report may be made at the 1928 Convention.

Revision of Section H of the manual

"Section H of the manual is in need of complete revision. The existing text is not well arranged and in a number of instances the meaning is not clear. A general revision has been undertaken and is presented herewith. In preparing this revision, the scope of the work of the committee has been grouped under four general subjects: Locomotive, Car, Motor Coach and Street Railway Lighting.

"The last two subjects have not, so far, been touched upon by this committee, but it is expected that there will be activity in these directions in the future. In the preparation of the revisions, herewith, it was found desirable to treat certain subjects, such as schedule of incandescent lamps, dimensioning of glass reflectors, etc., in more or less minute detail and more or less independently of the code of recommended practices. These subjects are classified as appendices and reference is made to them in the code.

"The revision of Section H, herewith, includes the following items:

(A) Code of recommended practices relating to locomotive lighting.
(B) Code of recommended practices relating to car lighting.
(C) Appendix A. Outlining in detail the existing method of photometry of locomotive headlights. If and when a more satisfactory method is developed, the new method will be offered as a substitute for the existing method.
(D) Appendix B. Dimensioning of reflectors for electric headlights. The method of dimensioning described is such that glass and metal reflectors may be directly compared and the membership is urged to insist that manufacturers list their dimensions, as outlined.
(E) Appendix C. Schedule of incandescent lamps for locomotive, car, motor car and street railway service.

"The revisions, herewith, have been made with a view to simplification and clarity. While the wording of the code has been changed in many instances, no material change has been made in the intent and purpose of the code, except as follows:

"Center Drive for axle generators has been recognized as the preferred form of application. Other forms of drive may and probably will be required in some instances. Such forms of drive are not prohibited in the revised code.

"The voltages for locomotive lamps have been modified by changing cab lamps from 33 volts to 34 volts, and headlight lamps from 32 volts only to 32 volts or 34 volts as desired. These changes are suggested by reason of the fact that some systems of train control employ voltages too high to permit the use of 32-volt lamp.

"It will be noted that no revision of the specifications for axle generators is offered. This is due to the fact that these specifications are now in process of revision. When this work is completed these specifications will be included as Appendix D.

"In view of the above, the committee recommends the withdrawal of all of Section H of the Manual and the substitution therefor of the revised Code of Recommended Practices and Appendices, accompanying this report.

Definition of the words "Lamp" and "Light"

"Considerable confusion has occurred in the work of this committee through the indiscriminate use of the words 'lamp' and 'light.' The committee has accordingly adopted for its use the definitions noted below and recommends that these definitions be accepted and used by the membership.

"Tht word 'lamp' shall mean the device, consisting of filament, bulb, base and other parts that is the source of or which generates light.

"The word 'lamp' shall mean the device, consisting of filathe lamp, reflector, housing, etc."

The report proper consists of specifications for locomotive lighting and car lighting. Except for a few minor details all of these specifications have been published previously in the Manual of the Association of Railway Electrical Engineers and are therefore not included herewith.

The report includes also three appendices. Appendix A outlines a method of photometering locomotive headlights and consists for the most part of a description of an improved photometer table. Appendix B covering dimensioning of headlight reflectors is included in the manual of the Association of Railway Electrical Engineers. Appendix C follows.

Schedule of incandescent lamps

Locomotive lighting service

Watts	Voltages	Bulb	Base	Remarks
15	34	S-14	Medium	Cab
15	34	S-17	Medium	Cab
*60	32 or 34	P-25	Medium	Head light
*100	32 or 34	P-25	Medium	Head light
250	32 or 34	P-25	Medium	Head light
**250	32 or 34	G-30	Medium	Head light

*The 100 watt lamp in inside frosted bulb is now being furnished and it is expected that it will, in the near future, supersede both the 60 watt and the 100 watt clear bulb lamps.

**The 250 watt lamp in G-30 bulb is being superseded by the same lamp in P-25 bulb.

Train lighting service

Watts	Voltages	Bulb	Base	Remarks
*15	32, 34, or 64	PS-16	Medium	....
*15	32, 34, or 64	G-18½	Medium	....
*25	32, 34, or 64	PS-16	Medium	....
*25	32, 34, or 64	G-18½	Medium	....
*50	32, 34, or 64	PS-20	Medium	....
75	32, 34, or 64	PS-22	Medium	....
*100	32, 34, or 64	PS-25	Medium	....

*The following inside frosted lamps are now in regular production. It is expected that they will supersede the above indicated lamps (*) and their use is, therefore, encouraged.

Watts	Voltages	Bulb	Base	Remarks
15	32, 34, or 64	A-17	Medium	....
25	32, 34, or 64	A-19	Medium	....
50	32, 34, or 64	A-21	Medium	....
100	32, 34, or 64	A-23	Medium	.. ....

Motor coach lighting service

Candle power	Voltages	Bulb	Base	Number	Remarks
3	6-8	G-6	DC-bay	64	Dash
6	6-8	G-8	DC-bay	82	Tail
21	6-8	S-11	DC-bay	1,130	Interior and hd. lt.
21	6-8	S-11	SC-bay	1,129	Interior and hd. lt.
3	12-16	G-6	DC-bay	68	Dash
6	12-16	G-8	DC-bay	90	Tail
21	12-16	S-11	DC-bay	1,142	Interior and hd. lt.
21	12-16	S-11	SC-bay	1,141	Interior and hd. lt.

The 3 and 6 candle power lamps may be used for sign, marker and auxiliary lighting.

Street railway lighting service

Watts	Voltages	Bulb	Base	Remarks
23	105, 110, 115, 120, 125, 130	S-17	Medium	....
36	105, 110, 115, 120, 125, 130	S-19	Medium	....
56	105, 110, 115, 120, 125, 130	S-21	Medium	....
94	105, 110, 115, 120, 125, 130	S-24½	Medium	....
23	105, 110, 115, 120, 125, 130	G-18½	Medium	Head light
36	105, 110, 115, 120, 125, 130	G-18½	Medium	Head light
56	105, 110, 115, 120, 125, 130	P-25	Medium	Head light
94	105, 110, 115, 120, 125, 130	P-25	Medium	Head light

The following gage lamps, 1⅛ in. maximum overall length, are for use in series with headlights.

Amps.	Voltages	Bulb	Base	Remarks
.214	3	T-3	Miniature	(In series with 23-w. hd. lt.)
.342	3	T-3	Miniature	(In series with 36-w. hd. lt.)
.519	3	T-3	Miniature	(In series with 56-w. hd. lt.)
.863	3	T-3	Miniature	(In series with 94-w. hd. lt.)

The lamps listed in this schedule are for use five in series on 525, 550, 575, 600, 625 or 650 volt circuits and should invariably be so ordered.

The report is signed by W. E. Dunham (chairman), Chicago & North Western; J. L. Minick, Pennsylvania; E. Wanamaker, Chicago, Rock Island & Pacific; E. W. Jansen, Illinois Central; A. E. Voigt, Atchison, Topeka & Santa Fe; E. Lunn, The Pullman Company, and H. A. Currie, New York Central.

Discussion

One of the speakers commented on the fact that the committee's report made no reference to voltage regulation. It was suggested that the voltage be allowed to rise from a normal of 32 volts to not exceed a maximum of 33½ volts and that a minimum of not less than 30½ volts be permitted. This, it was stated, is a total variation from a minimum to maximum of nearly 10 per cent which should be easily met by a first class modern turbo-generator. It was also suggested that the committee make an effort in conjunction with the manufacturers to determine upon a standard headlight case.

It was proposed that the committee change the wording of its report under the heading of specification and marker lights to read: "If electric classification and marker lights are used, they shall be applied as required by the A. R. A. code of train rules." As written, the speaker said, it may be implied that electric classifications and marker lights shall be applied. In addition, it may have been the committee's thought that so-called white "back-up" lights should not be used.

It was also proposed that it might be well to segregate the Locomotive Lighting Committee from that of the Car Lighting Committee, due to the fact that locomotive headlighting equipment is a source of energy for train control operation as well as the lighting of the locomotive. A separate committee could be provided to report on electric car lighting, it was suggested, the equipment for which is more nearly standardized and there are fewer problems to solve than is the case with electric equipment on a locomotive when operated in train control territory.

Objection was also raised to the size of the steel inlet at the turbo-generator which the committee designated should be of ½-in. iron pipe. The present tendency seemed to be toward a ¾-in. pipe. *The report was accepted.*

Economic aspects of railway equipment

Influence of locomotives and cars, and their maintenance on operating and financial results

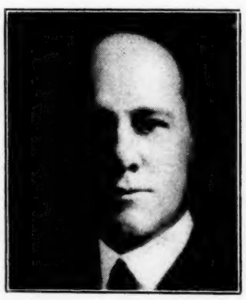
During the Montreal convention of the American Railway Association, Mechanical Division, an address was delivered by William J. Cunningham, professor of transportation, Harvard University, and a paper was presented by W. T. Jackman, professor of political economy, University of Toronto. Both dealt with aspects of railway economics which are particularly related to the ownership of cars and locomotives and to the work of the mechanical departments in maintaining this equipment. Professor Cunningham dealt particularly with the importance which capital investment has played in the improvement of railway service and railway operating efficiency during recent years, and he pointed out specifically that while the striking increase in freight transportation efficiency has been purchased in substantial part by heavier costs in maintenance of locomotives, the net result has been a lower total ton-mile cost and the ability to increase the capacity of the lines and terminals.

Professor Jackman's paper, which also analyzed the operating results of the railroads over a number of years to point out the factors influencing the financial results, stressed the importance of more intensive utilization of equipment and terminals. Abstracts of Professor Cunningham's address and Professor Jackman's paper follow:

Equipment expenditures and transportation efficiency

By William J. Cunningham

Professor of transportation, Harvard University, Cambridge, Mass.



W. J. Cunningham

Since the beginning of the present century the expenses of maintaining equipment have increased relatively much more than other expenses, but the additional expenses in maintaining equipment have purchased economies of much greater magnitude in transportation. The remarkable increases in operating efficiency during recent years, particularly in the period since the war, are creditable in large part to advances in the design and maintenance of locomotives and cars, and the importance and prestige of the mechanical department in railroad organization as a whole have been correspondingly enhanced.

The fact that the expenses of maintaining locomotives

and cars have been increasing steadily and in greater degree than the increases in other departmental expenses is fairly well known, but is not generally comprehended either as to extent or in significance. Prior to 1904 the total expenses for maintaining equipment were less than those chargeable to maintenance of way and structures. In 1904 the two groups of expenses were practically the same. Since then the tendency has been for maintenance of way and transportation expenses to decline relatively and for maintenance of equipment expenses to grow relatively.

Because of changes in the accounting classifications of the Interstate Commerce Commission it is not possible to make a scrupulously exact comparison of the 1926 expenses by general accounts with those of any year prior to 1915, but with slight qualifications the comparison may be extended backward to 1908. Prior to 1908 the transportation expenses included nearly all of the expenses now classified in the group called "traffic expenses," as well as the net debit or credit balances for joint use of freight cars, hire of other equipment, and rent of facilities, now transferred from expenses to additions to or deductions from income. Yet by making adjustments which in greater part compensate for these differences in accounting methods it is possible to afford an approximate comparison of the results in 1926 with those in 1901, a period of 25 years. Such adjustments have here been made in the 1901 figures, as the transportation expenses have been restated. The 1901 figures are for all railroads in the United States. Those for 1926 are for Class 1 railroads only, but inasmuch as the significance of the comparison lies in the relative percentages of increase and in the changes in relative proportions of total, this discrepancy in the basic figures has little bearing upon the comparative indices.

These figures indicate strikingly the reversal of relationship in the two maintenance accounts and the substantial reduction in the relative magnitude of transportation expenses. In 1901 the maintenance of way ratio to the total was 23.4 per cent while the maintenance of equipment was but 19.2 per cent. In 1926 the way and structures ratio fell to 18.5 per cent, while the equipment ratio advanced to 27.4 per cent. Transportation declined from 51.0 per cent to 46.9 per cent. Or, in other comparative terms, the 25-year increase in way and structures total was 278 per cent; in transportation it was 337 per cent; while in equipment it was 579 per cent. The increase in equipment expenses was over twice as great relatively as the increase in way and structures, and was nearly one and three-quarters as great relatively as the increase in transportation expenses.

Total operating expenses for 1926 compared with 1901

	1926	1901	Per cent increase 1926 over 1901	Per cent of total 1926	Per cent of total 1901
M. of W. and S.	$874,244,048	$231,056,602	278	18.5	23.4
M. of E.	$1,291,919,172	$190,299,560	579	27.4	19.2
Transportation	$2,209,245,908	$505,163,886	337	46.9	51.0
Other	$339,612,750	$63,653,915	433	7.2	6.4
Total	$4,715,021,878	$990,173,963	376	100.0	100.0

Turning from the 25-year comparison, in which the earlier figures are subject to some qualification because of changes in accounting methods, we may place the 1926 figures alongside of those for 1908, the first year under the accounting classification effective July 1, 1907. Since then there have been but few changes in the general accounts and, with but one adjustment for maintenance of work equipment, the 1908 figures may safely be compared with those of 1926.

While the degree of change in the relationships between departmental expenses was not as striking as in the 1926-1901 comparison, nevertheless, the differences are notable. Between 1901 and 1908 the equipment expenses grew so fast that in 1904 they exceeded the way and structures expenses where as in 1901, equipment was the lower of the two. During the 18-year period from 1908 to 1926 way and structures expenses showed little change in their relation to the total—19.3 per cent in 1908 and 18.5 per cent in 1926—but the equipment expenses jumped from 22.5 per cent of the total in 1908 to 27.4 per cent of the total in 1926, and transportation expenses were reduced from 52.1 per cent of the total in 1908 to 46.9 per cent of the total in 1926. In other terms, the increase in transportation expenses during the 18-year period was 159 per cent, the increase in way and structures maintenance was 178 per cent, and the increase in equipment maintenance was 253 per cent. The absolute increase in equipment maintenance was 1.4 times as great as the absolute increase in way and structures maintenance, and 1.6 times as great as the absolute increase in transportation expenses.

Total operating expenses for 1926 compared with 1908

	1926	1908	Per cent increase 1926 over 1908	Per cent of total 1926	Per cent of total 1908
M. of W. and S.	$874,244,048	$314,100,349	178	18.5	19.3
M. of E.	$1,291,919,172	$366,168,273	253	27.4	22.5
Transportation	$2,209,245,908	$851,443,784	159	46.9	52.1
Other	$339,612,750	$99,797,548	240	7.2	6.1
Total	$4,715,021,878	$1,631,509,954	189	100.0	100.0

The significance of the changed relationships

The proportionately greater cost of maintaining locomotives and cars than of maintaining way and structures and of conducting transportation, is not an indictment of the efficiency of the mechanical department. Instead, in the main, it is the reflex of important advances in the art of transportation. The notable achievement in the constant increases in the train load and otherwise in producing more units of transportation—ton-miles and passenger miles—with less units of work—locomotive miles, train miles, car miles, train crew hours, and tons of fuel consumed—have been made possible in large part by the steady development in the power, capacity and efficiency of equipment. Heavier and more powerful locomotives, with economizing devices such as superheaters, feedwater heaters, mechanical stokers, boosters and the like, and the use of larger capacity cars, produce more ton-miles per train miles, per train crew hour and per ton of fuel, but they add to equipment maintenance costs. The striking increase in freight transportation efficiency, then, has been purchased in substantial part by heavier costs in maintenance of locomotives and cars but the net result has been a lower total ton-mile cost and the ability to increase the capacity of lines and terminals.

Effect of modern facilities and equipment on maintenance expenses

It may be suggested that the heavier trains and the use of heavier locomotives and cars have necessitated heavier rails, more ties, more ballast and in general higher standards in the entire roadbed, track superstructure and structures, as well as in the maintenance cost of shops, enginehouses, fuel stations and other structures and facilities devoted to equipment use but chargeable to the maintenance of way and structures, and that therefore the cost of maintaining way and structures would be burdened correspondingly. Yet while it is true that modern equipment and modern methods of train opera-

tion demand higher standards in way and structures it does not follow that the total of way and structures maintenance expense should increase relatively as much as equipment maintenance.

Improvements in way and structures do not entail additional maintenance costs in the same degree as the developments in locomotives and cars increase equipment maintenance costs. In fact, many of the developments in way and structures actually reduce rather than increase the maintenance burden. The return from a large part of the advances in maintenance of way engineering are in the form of reduced maintenance of way expenses as, for example, in treated ties. Another substantial part, as with deeper or better ballast, heavier rails, and steel or concrete structures instead of wood, bear heavily upon capital expenditures and yield their return in the lower cost of upkeep. Similarly, the capital account assumes the greater part of the cost of reducing grades and curvature but the benefit accrues both to maintenance of way expenses and transportation cost.

The essential difference between the development in way and structures on the one hand and locomotives and cars on the other hand, is that the better way and structures yield economies in maintenance as well as in transportation, while the heavier locomotives, with their complicated economizing devices, and the larger capacity cars, add substantially to equipment maintenance costs and almost the entire benefit accrues in the form of lower transportation costs.

Recent improvements in operating efficiency

It would be neither fair nor proper to press the point unduly that the advances in equipment standards have been responsible for the recent remarkable achievements in transportation efficiency. To those in executive positions who have had the vision and the courage to take the responsibility for the very large additional capital expenditures since the war, due credit must be given. The enlargements and improvements in terminals, running tracks, automatic signaling, heavier bridges and improved structures and other facilities, have contributed their part. The improved service of the supply department has had its influence on the efficiency of maintenance. And finally, the steady increase in the skill, resourcefulness and energy of the transportation department should be adequately recognized. Yet with due credit to all other branches of the service, the mechanical department deserves high tribute for the substantial and steady advance in designing equipment to meet effectively and efficiently the heavier demands of transportation and for maintaining locomotives and cars so that the transportation department could give adequate and dependable service.

Except in the important factor of return on property investment, the railroad record of 1926 is one of superlatives. It had the largest volume of ton-miles, the greatest operating revenues, the largest net income, the highest operating efficiency, and the standard of public service was never before equalled in quality. The record as a whole is encouraging to those, charged with the determination of executive policies, who during the past six years have courageously invested about $800,000,000 per year in capital improvements on the railroads of the United States, even though the return on the total investment in a year with such favorable results otherwise is disappointingly low. That courage is born of a faith that the Transportation Act of 1920 means what it says in Section 15-a, namely, that the railroads as a whole, or collectively in territorial groups, shall be permitted to earn a fair return on the value of property devoted to public service, if operated with honesty, efficiency and economy. The return last year was better than in any year since the act was passed but it was too far short of a fair return.

It is not my intention to enter upon a discussion of this highly important phase of economics. I refer to it merely to give me the opportunity to develop the point that in so far as operating efficiency is concerned the railroads are before the public with clean hands.

Four years of progress in operating efficiency

It is not necessary to go back many years to demonstrate the striking gains in transportation efficiency. The comparison may be limited to 1926 and 1922. In taking 1922 as the base I am passing up the opportunity of showing the greater gains that would be apparent if 1921, the first complete year under the 1920 law, were taken as the base. But 1921 was a year of subnormal traffic and may not fairly be used. To a certain extent the 1922 base was adversely affected by the strike of shop employees, but the results of that strike bore more heavily upon 1923. The program of additions and betterments, which as already mentioned has resulted in yearly additional investments of about $800,000,000, was well under way in 1922.

Here are a few of the significant indices of operating efficiency in the two years—1922 and 1926. The traffic density in net ton-miles per mile of road per day in 1922 was 4,405; in 1926 it was 5,688, an increase of 29 per cent. With the larger volume of traffic it would be natural to look for more economical performance but in this case the increase was so substantial as to invite congestion through the overtaxing of facilities. Instead of congestion, however, the year 1926 was practically free from any interruption to expeditious movement or from any shortage of equipment. The service was never so free from congestion, delay and car shortage, although the volume of traffic exceeded all previous records.

In train operation the following are the significant units. The gross train load in 1922 was 1,466 tons; in 1926 it was 1,737 tons, a gain of 271 tons or 18 per cent. The net train load in 1922 was 677 tons; in 1926 it was 772 tons, an increase of 95 tons or 14 per cent. The smaller gain in net than in gross appears to be due to the greater percentage of empty car movement in 1926.

The train speed in 1922 was 11.1 miles per hour; in 1926 it was 11.9 miles per hour, an increase of seven per cent.

If the gross ton-miles of 1926 had been produced by trains of the same weight as those of 1922, the 1926 train miles would have been 749,447,000 instead of 632,557,000, an excess of 18 per cent. The heavier train load of 1926 saved 116,890,000 freight train miles.

This estimate of saving, however, takes account only of the better train load. It neglects the gain in train speed. Both load and speed are combined in the unit "gross ton-miles per train hour." In 1922 the gross ton-miles per freight train hour were 16,213; in 1926, they were 20,705, an increase of 28 per cent. If the 1926 freight traffic had been moved with the 1922 efficiency in train load and train speed, the train hours would have been 67,766,113 instead of 53,064,819. The higher degree of efficiency in 1926, therefore, saved 14,701,294 freight train hours or 28 per cent in those expenses which vary directly with train hours.

In 1922 the fuel consumption was 163 lb. per 1,000 gross ton miles; in 1926 the comparable unit was 137 lb., a saving of 26 lb. or 16 per cent in fuel cost. If the 1926 fuel efficiency had been the same as in 1922 the fuel consumption in freight train service in 1926 would have been 101,563,181 tons instead of 85,058,218, an increase

of 16,504,963 tons or 19 per cent in the fuel bill for freight service alone. Likewise, in passenger service if the 1922 unit of 17.9 lb. per car mile had been in effect in 1926 (instead of 15.8 lb.) the fuel consumption in passenger service would have been 33,937,308 tons instead of 29,999,277 tons, an increase of 3,938,031 tons or 13.1 per cent in the fuel bill for passenger service. Combining both freight and passenger services, but not including yard service (for which the data are not available on a unit basis) the decrease in the cost of fuel in train service in 1926, because of superior equipment and better operating methods in comparison with 1922, was about 20½ million tons.

The gains in freight car efficiency are similarly impressive. The car miles per car day in 1922 were 23.5; in 1926 they were 30.4, a gain of 29 per cent. The average car load in 1922 was 26.9 tons; in 1926 it was 27.4 tons, an increase of 2 per cent. Where there was a slight decrease in the percentage loaded of total car miles, the resultant of the three factors—net ton miles per car day—was a marked improvement, 424 in 1922 and 532 in 1926. The gain in the ton mile productivity of cars, therefore, was over 25 per cent. If the 1926 traffic had been handled with the 1922 freight car efficiency, the cars required to produce the 1926 ton miles would have been 3,155,000 or 637,000 cars more than were actually available. The better utilization of cars in 1926 was made possible mainly by the quicker turnover at terminals, the smaller delay at inspection and interchange points and in repair yards and shops, the speedier movement on the line, and the reduction in the number of unserviceable cars from 12.8 per cent in 1922 to 6.5 per cent in 1926.

These are the high spots in the 1926 record. Many other evidences of substantial improvement in efficiency might be cited as well as the intangible but highly important factor of quicker dispatch and dependability of service from the viewpoint of the public. The higher quality of service since 1922 has brought about what is almost a fundamental change in purchasing policies so that manufacturers and merchants are getting along with much smaller inventories and in many cases are saving a substantial part of the freight bills by the reduction in the interest charges on their smaller stocks.

As has already been stated the recent achievements of railroads are the results of capital improvements, better equipment and facilities, better operating methods, and better team work on the part of all departments of the service. To these commendable results the mechanical department has made substantial contributions and its officers of all grades have abundant reason to feel proud of their part in the satisfactory performance.

The relation of physical factors to financial results

By W. T. Jackman

Professor of political economy, University of Toronto

W. T. Jackman

The financial returns obtained by a railway company depend upon the general level of freight rates, on the one hand, and upon the operating expenditures and capital charges on the other. The relation of rates to financial returns is immediate and direct; and, although by far the larger share of public attention with reference to the railways is given to the freight rates, it is not our purpose here to consider this matter. Instead, we shall confine our attention to the other aspect of the problem, namely, the relation of the physical elements of operation to the financial results.

Public interest is frequently centered on the relation of earnings to the railroad capitalization, sometimes because the former are inadequate to meet the demands of the latter and a readjustment of the capital becomes necessary, and at other times because, notwithstanding many difficulties, the railway companies are able to pay reasonable dividends and expand with, and occasionally in advance of, the growth of the country. But it is much less frequently that one finds any consideration given by people generally to the relation of earnings to the value of the physical plant by the use of which these earnings are obtained.

An analysis of the operation of 10 roads

In order to give a conspectus of the present problem with the necessary background for appraising it, we have worked out the accompanying table with some degree of elaboration from the actual figures presented in the annual reports of ten important railways of the United States and Canada. We have used the figures for the year 1910 as a base, because this was a year of approximately normal development, and have traced the changes through the period of the war and of the subsequent restoration. On the basis of 100 for the year 1910, we have expressed the facts for succeeding years in terms of percentages of those for 1910. It will be recognized that a composite picture obtained from the returns of many railroads, operating under a wide diversity of conditions will give a more exact foundation for our analysis than could be obtained from the facts pertaining to only one or two railroads.

Table I—Relative figures of physical and financial results of operation of a group of ten railroads* using the year 1910 as the base

Year	No. of miles operated	No. of locomotives	No. of revenue freight cars	No. of passenger cars	Other equipment	Value of railway and equipment	No. of ton-miles of revenue Freight	No. of ton-miles of revenue freight per mile of road	Total freight revenue	Total passenger revenue	Gross operating earnings	Operating expenses	Net operating earnings	Per cent return on value of railway and equipment
1910	100	100	100	100	100	100	100	100	100	100	100	100	100	10.1
1911	100	103	96	101	70	102	104	103	104	99	104	100	114	11.0
1912	100	104	101	101	70	109	112	112	111	104	110	109	110	8.0
1913	99	109	110	106	76	139	122	123	118	112	116	118	112	8.1
1914	99	112	108	114	75	183	106	107	106	105	113	113	111	6.1
1915	147	137	181	123	106	284	190	127	179	126	168	148	222	8.0
1917	150	138	191	122	122	311	243	162	188	157	216	207	242	7.8
1919	160	166	201	143	133	336	217	149	297	237	284	304	227	6.8
1921	161	151	189	128	119	351	160	106	306	253	292	299	272	7.8
1923	182	144	166	114	116	370	245	163	402	270	365	376	335	9.1
1924	182	169	197	139	145	389	227	125	388	302	370	378	347	8.9
1925	183	162	190	137	143	399	242	133	410	304	386	392	370	9.3

* Nine roads in the eastern and central part of the United States and one in Canada.

Having this table before us, let us note some of the important facts which may be adduced from it.

First.—With an increase of 62 per cent in the number of locomotives and an increase of 90 per cent in the number of freight cars, the amount of service rendered, i.e., the number of ton-miles of freight carried, increased 142 per cent, although the density of traffic, i.e., the number of ton-miles per mile of road, increased only 33 per cent. This gives a clear indication of the more intensive use of the rolling stock at the later than at the earlier time.

Second.—Although the amount of service rendered increased by only 142 per cent, the gross operating freight revenue increased by 310 per cent. This shows the effect of the higher freight rates in the period during and since the war.

Third.—Although the gross operating earnings increased by 286 per cent, the operating expenses increased still more, so that the net earnings from operation increased only 270 per cent. During this period the operating expenses (wages, fuel, materials, etc.) rose proportionately higher than the freight rates charged for the service. Over these operating expenses the railroads have almost no control—wages are determined largely by the labor unions, while the prices of fuel, materials and supplies are almost entirely in the control of those who supply these requisites. With freight rates under the control of the regulative tribunals and the operating expenses in large measure beyond the c•ntrol of the railroads, it is not surprising that the net earnings from operation have not kept pace with the gross earnings.

Fourth.—A very important thing to note is that while the amount of the service rendered by the railroads, that is, the number of ton-miles of revenue freight carried, increased only 142 per cent and the gross earnings from operation increased by 286 per cent, the investment of capital in roadway and equipment increased practically 300 per cent. This taken in conjunction with the fact noted first above that there has been a more intensive use of the rolling stock, leads to the explanation that this great increase in capital investment was not necessary for the existing business but was made to a considerable extent so that the railroads might be ready to meet any emergency in the way of an unusual volume of traffic which may arise in the near future. The railroads must be constantly preparing for the unexpected. Even under normal conditions the amount of traffic which is offered to the railways increases much more than proportionately to the increase of population; and when the traffic is stimulated or encouraged but slightly the amount of increased business comes with a rush upon the rails. Unless the railway company has made provision in advance for meeting such an emergency, it would be unable to make provision for it at all, for there would be no time for this when the flood of traffic was at hand.

Fifth.—With the exception of a few years during and immediately after the war, when business conditions were disorganized, the net earnings were fairly uniformly 8 per cent and 9 per cent of the value of the railroads' investment in roadway and equipment. Of course, the entire investment of the railway companies does not consist merely of roadway and equipment, but includes a great variety of other elements, such as cash, materials, supplies, accessories, etc., which would, on a conservative estimate, increase the amount of this operating investment by 5 per cent. But before anything can go to the owners of this investment, that is, the stockholders, provision must be made for meeting the fixed charges on the bonded debt, as well as for a variety of reserves which are necessary, and care should be taken to set aside a reasonable surplus to meet unforseen contingencies. If all these demands were adequately satisfied, the amount which the companies could divide among those whose capital provided the operating assets would be small indeed. The return of 8 per cent to 9 per cent upon the railway plant and facilities is entirely inadequate. According to the last report of the Interstate Commerce Commission, issued a few weeks ago, the average rate of return on dividend yielding stock of Class I railroads in 1925 was 6.51 per cent, and if the dividends had been divided out over all the stock of these railroads the return would have been only 4.45 per cent. For the Class II and III railroads the dividends are practically negligible. If all the railway dividends paid in the United States in 1925 had been allotted to the entire amount of railway stock, the return would have been but 4.35 per cent, which is but little more than the rate allowed on savings bank deposits.

Attention concentrated on economies in operation

Confronted with these financial difficulties and with a virtual impossibility of securing increased rates which would pay the return suggested as reasonable by the regulative commission, the railroads have turned their attention to the development of the greatest possible economies in operation.

In the first place, the average capacity and weight of freight cars is constantly increasing. This means that the railroads are hauling more dead weight per car, and unless there is a corresponding increase in the load carried the result will be an increase of operating expenses without a proportionate increase of revenues. There is no doubt whatever as to the economy of large cars when they can be loaded approximately to capacity; but, on the contrary, if they are not so loaded the greater cost and the greater weight of these cars will be a constant drain upon the earnings of the road. The conditions as to loading may be exemplified by reference to to Table II.

From this it is evident that from 1903 to 1913 a smaller percentage of the car capacity was filled with paying freight; but during the war, when heavier loading was encouraged so as to utilize equipment to the fullest extent, the average load occupied a considerably larger proportion of the car capacity. Since that time the proportion of the car capacity which is filled with the paying load has again declined until in 1925 it was below what it was in 1903. The results in 1918 showed that no interest was injured by the heavier loading of the cars and there seems to be no good reason why that policy should not have been continued. The average loading of 1925 was 9.9 per cent less than that of 1918. If the loading in 1925 had maintained the standard of 1918 the average revenue load of 1925 would have been 24.55 tons + 10 per cent (approximately) of 44.8 tons, that is, instead of 24.55 tons it would have been 29.03 tons. The extra 4½ tons could be carried with little, if any, increase in the operating expenses and the additional revenue received from such heavier loading would have been in the aggregate very large. It would have been a great financial assistance to the carriers, while the shippers would not have been burdened or hampered in their business.

Table II

Year	Average capacity of freight cars (tons)	Average revenue load per loaded freight car (tons)	Revenue load per freight car as a percentage of the average car capacity
1903	29.4	17.60	59.9
1913	38.3	21.12	55.1
1918	41.6	26.90	64.7
1923	43.8	25.18	57.5
1925	44.8	24.55	54.8

Heavier car loading an important factor

The most important single means of increasing the efficiency and economy of railway operation is through the heavier loading of cars, so that the amount of the load may correspond more nearly with the car capacity. By this means the three large classes of expense, namely, those for transportation, maintenance of way and structures and maintenance of equipment, may be reduced per unit, when the larger amount of the load can be carried for the same or a slight increase of expense and thereby the operating cost may be borne by a larger paying load. In the last six years, since the railroads of the United States were handed back to their owners, great progress has been made in reducing operating expenses. This progress would have been much greater if the average loading had been maintained at the war level.

In 1926 the average load per car for all commodities was 27.4 tons. If this average load per car had been increased by one ton, the same transportation service could have been effected by 80,000 fewer cars, which, at an average cost of say $2,000, would have represented a saving in railway capital investment of $160,000,000. This economy of capital to the railway companies would be accompanied by corresponding possibilities of economy to the users of the service, for with the heavier loading there would be lower unitary expenses of rendering the service and this would make it possible for the carriers to lower their rates.

But how is this heavier loading of cars to be obtained? It will be evident at once that while many commodities cannot be loaded into cars to the maximum load limit, many others can be loaded to this limit and sometimes beyond it. In order to attain this end there must be co-operation between the shipper and receiver of freight and the carrier. It is necessary to create an intelligent interest in this matter among all those connected with the service and to elicit a better understanding of what an increased or decreased load produces in the way of decreased or increased operating costs and car efficiency. The facts concerning these matters must be kept constantly before the shipping public and the railroad employees. Shippers must be made to realize that, by more complete loading of cars, they have it in their own power to secure cheaper and more adequate service.

The railroad employees should also be instructed and encouraged to contribute toward this end, for they are responsible for the loading of most of the less than carload freight. This loading process is entrusted in too many instances to men who are in the lowest ranks of railway labor and who have never been shown how to load small shipments so as to use most effectively the car space and to prevent damage to the goods.

Another of the large problems with which the railroads are confronted is the greater utilization of their equipment, terminals,

etc. In most cases the terminals are situated in those sections of the city where land is of the highest value because of its intensive use and demand. Consequently, they are subject to a heavy burden of fixed charges on their capital cost and a correspondingly heavy tax imposition. It is essential, therefore, that traffic should be moved as rapidly as possible through the terminals, for while it is standing on the yard tracks it is not earning any revenue for the railway company. The same thing may be said for the movement along the line; the more rapid the transportation the more fully are the roadway and rolling stock being employed in producing revenues, but the longer the cars are standing on sidings and at way stations the less revenue they are producing. Moreover, why should obsolete cars and locomotives be allowed to occupy space in the terminal yards and on the road when their costs of obsolescence and repair are greater than the revenue they yield?

The increasing speed with which freight cars are being moved is shown by the fact that the number of miles per freight car per day increased from an average of 25.7 miles in 1921-1925 to 28.5 in 1925 and 30.4 miles in 1926. These figures, taken in connection with the fact that the number of ton-miles per car day increased from an average of 457 in the five years, 1921-1925, to 495 in 1925 and 532 in 1926, represent a very decided advance in the utilization of freight cars.

A similar improvement is noted in locomotive performance, for the number of locomotive-miles per freight locomotive day increased from 55.1 as the average for 1921-1925, to 58.3 in 1925 and 61.8 in 1926. Then, too, the numbers of unserviceable freight cars, which in 1921 were 13.1 per cent of the total, were reduced to 6.5 per cent in 1926, and the numbers of unserviceable locomotives, which in 1921 were 23.7 per cent of the total, were reduced to 16.4 per cent in 1926.

The question of depreciation and obsolescence is one which should engage attention. Indeed, this issue has been forced to the front by the recent decision of the Interstate Commerce Commission concerning depreciation. Out-of-date equipment takes up valuable accommodation on the railway tracks and the expense for repairs which is frequently as much as, if not more than, for the better modern equipment. The time spent under repair should be so short that the cars may be kept in service a large proportion of the time, so that, with intensive use, they may render the greatest service in the way of ton-miles per day and per year. The same thing may be said regarding locomotives.

In this intensive use of equipment, it is desirable to concentrate the load into larger and larger units. By increasing the trainload, or the number of tons per train, the large train can be handled with but a slight increase of expense over the smaller train, and the large proportion of constant operating expenses can be divided over a larger paying load, so that the unitary expense is reduced correspondingly. Short haul and predominantly less than carload traffic cannot be concentrated into heavy trainloads; but for the sake of economy all railroads are alert to combine their traffic in this way into larger movable units.

Capital, wisely invested, yields a surplus return

The last subject which we wish to consider here is that of capital expenditures in plant and equipment. In Table I we have shown that the increase of capital investment in roadway and equipment exceeds that of nearly every other factor, and at first we are surprised to find this. It would seem that, while operating expenses were keeping well ahead of gross operating earnings and much in advance of net operating earnings, the railway policy would have been to restrict its investment in these forms of capital. In the case of a manufacturing establishment, if operating expenses were proportionately greater than operating income, this would not be a suitable time for enlargement of plant and expansion of operations. But in the case of a railroad the conditions are entirely different fundamentally from those that are found in a manufacturing establishment.

It is found that as the railway expends judiciously upon its line in eliminating gradients and curves and in securing a more substantial and better ballasted roadway, its operating expenses are correspondingly decreased. The same result accrues from improvement of terminals, by means of which the cost of handling traffic through the terminals is reduced and the acceleration of traffic movement is promoted. So, too, in the case of rolling stock: the most improved types of engines, with greater tractive force and less fuel consumption, and the larger and more substantial cars, with their greater carrying capacity and lower proportionate tare, are improvements which contribute very decidedly to economical operation.

Since the railway company has very little control over its rates, from which its revenues are obtained, and since more than half of its operating expenses are practically beyond its control, it is natural that the company should use every appropriate means within its reach to reduce that part of the operating expenses which is under its control. And this, as we have noted above, is effected to the greatest extent through heavy capital expenditures for roadway and equipment. Capital investments, when made with discretion, will usually yield a surplus return over and above the cost of the capital and this is an additional inducement. Besides, there is the fact mentioned a little earlier that these large capital expenditures are necessary in order to make provision for the inevitable increase of future traffic in a growing country and for the possibilities of an emergency rush of business which may come on very short notice. Even although these large increases of capital receive but a low net return, yet they must be made, for reasons just mentioned.

The relative amounts of these expenditures for equipment and for roadway and structures is interesting, as shown in Table III.

The figures for 1926 are as close an estimate as we can get at the present time. For a few years previous to 1923 the amount spent for equipment was much greater than that spent for way and structures, but from 1923 onward the tendency has been to increase the percentage of the total capital expenditures which are devoted to roadway and structures, that is, to those facilities which further the more intensive use of the equipment, and a smaller percentage to the equipment itself. This tendency indicates a return to the more normal pre-war conditions, when approximately one-third of the capital expenditures were for equipment and two-thirds for fixed plant.

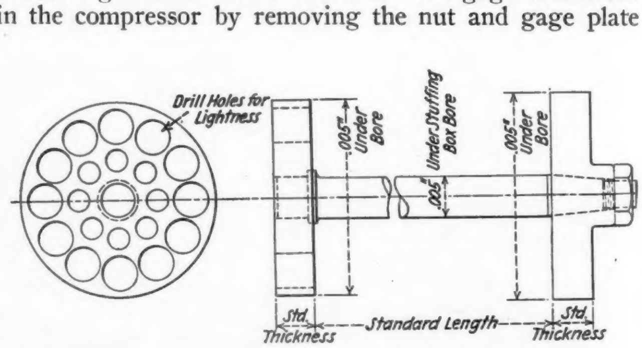
Table III

Year	Total capital expenditures	Expenditures for equipment	Per cent of total	Expenditures for roadway and structures	Per cent of total
1922	$429,272,836	$245,508,801	57	$183,764,035	43
1923	1,059,149,426	681,723,991	64	377,425,435	36
1924	874,743,228	493,608,460	56	381,134,768	44
1925	748,191,000	338,114,000	45	410,077,000	55
1926	875,000,000	380,000,000	43	495,000,000	57

Finally, notwithstanding the well-merited emphasis upon the physical factors of railway operation, the personal and human element is of much greater importance. Without the co-operation of an interested, intelligent and faithful body of employees with an equally intelligent and human management, the whole organization would be as hard and unresponsive as the rails upon which the traffic move. In the words of the late President Smith, of the New York Central System, "Ninety-five per cent of this railroad business is human; the rest is largely steel and coal."

Lining gage for air compressors

THE device shown in the drawing is designed for gaging the steam and air cylinders of an air compressor for surface contour and alinement after the inside lining has been turned to size. The gage is inserted in the compressor by removing the nut and gage plate



Separate gages of this design are used for each size of air compressor

and thrusting the rod through the two stuffing boxes separating the steam and air cylinders. The gage plate and nut is then replaced and both cylinders are gaged for any irregularities in piston rod alinement or cylinder lining surface by moving the gage back and forth in the cylinders.

Utilization of cars and locomotives

During 1926 practically all operating factors reached the highest points ever attained

THAT the railroads have, during 1926, reached the highest point yet attained in the utilization of cars and locomotives was set forth in a committee report and three individual papers presented at the Mechanical Division convention of the A. R. A. held at Montreal during the week of June 6. The report on Locomotive Utilization pointed out that during 1926 the freight traffic and operating revenues were the largest ever recorded, while practically all operating factors reached the highest point ever attained. The report contained helpful suggestions as to the compilation of statistics for supervising the utilization of locomotives. Of particular interest was the discussion of the problems involved in the dispatching of locomotives and trains. Scattered throughout the report were references to the improvements made in locomotive utilization through extended runs.

A. G. Pack, chief inspector, Bureau of Locomotive Inspection, I. C. C., complimented the railroads on the splendid condition of the locomotives. Mr. Pack aptly propounded a basic fact pertaining to locomotive maintenance by stating that "A few cents per mile added to the necessary cost of maintenance is more than compensated for by the reduced cost of transportation."

In his address, M. J. Gormley, chairman, Car Service Division, showed how effectively the program of the railroads to provide adequate transportation service had been carried out, and discussed some future possibilities. In addition, Mr. Gormley presented some interesting data pertaining to car distribution, to efficiency in car handling, to capital expenditures and operating expenses and to adequacy of transportation. In a recent report of the Car Service Division, it was stated that it is possible to handle the traffic of the country for some time to come with a total decrease in the ownership of open top and box cars of at least 100,000 depending on five conditions which were set forth by Mr. Gormley.

L. K. Sillcox, chairman of the Mechanical Division, devoted his address to the subject of more intensive use of equipment, in which he set forth clearly by means of charts and figures what has been done in reducing maintenance expenses and improving the design of equipment.

Report on locomotive utilization

T. B. Hamilton
Chairman

The development of the American railroads has made the utilization of locomotives a very important and necessary subject. The magnitude of investment in locomotives, character of facilities necessary for their maintenance and their preparation for service and the cost of actual repairs, have reached such proportions that railroad officers are directing much study and consideration to securing the maximum return from each locomotive consistent with maintenance expense.

To obtain data bearing upon this subject and to study locomotive utilization, maintenance and facilities on the ground under the various conditions, field surveys were made on the following systems:

Union Pacific	Southern Pacific
Atchison, Topeka & Santa Fe	Florida East Coast
Louisville & Nashville	Missouri Pacific
Illinois Central	Chicago, Milwaukee & St. Paul
Pennsylvania	Northern Pacific
Baltimore & Ohio	Canadian National
New York Central	

These roads, covering a wide range of territory, operating conditions and traffic requirements gave your committee the fullest opportunity to study this subject. Detailed information covering surveys made is on file with the American Railway Association, Mechanical Division, and is available to executive officers of member roads.

The year 1926 was the greatest in the history of the railroads in the United States, freight traffic and operating revenues being the largest ever recorded, while practically all operating factors reached the highest point ever attained. Freight traffic as measured by gross ton miles increased 7.4 per cent over 1925 and 11.3 per cent over 1923, each of these years breaking all previous records of business handled; net ton-miles, which included both revenue and non-revenue tonnage, increased, 7.1 per cent over 1925 and 6.8 per cent over 1923.

Apart from the detailed explanation as to the larger capacity of the average active engine in service it will be observed the average miles per day per active freight and passenger locomotive for Class I railroads increased as follows:

	Freight	Passenger
1923	81.6	142.6
1924	79.1	143.0
1925	82.3	147.7
1926	85.0	151.9

During the year 1926, an average of 154.8 lb. of coal was required to haul 1,000 tons of freight and equipment, excluding locomotive and tender, a distance of one mile as against 158.9 lb. in 1925, a substantial decrease being recorded each year against the 1922 unit of 186.0 lb.

The number of miles per freight locomotive owned per day in 1926 averaged 61.8 compared with 58.3 for 1925, 55.3 for 1924, 60.3 for 1923 and 52.0 for 1922. In like manner on the basis of active locomotives. To fully comprehend what a great net improvement this is, we must bear in mind the increased work each locomotive is doing while increasing this mileage. Since 1922 the average road speed increased 7.2 per cent, gross tons per train increased 18.6 per cent and gross ton miles per train hour increased 27.9 per cent, and decreased the fuel consumed per 1,000 gross ton miles 16.8 per cent.

The percent of unserviceable freight locomotives owned also decreased to 16.4 per cent in 1926 compared with 17.8 per cent in 1925, 18.8 per cent in 1924, 21.6 per cent in 1923 and 25.5 per cent in 1922. While the gross tonnage handled in 1923 broke all records up to that time, 1926 exceeded this year by 11.3 per cent and at the same time recorded a decrease of 1,621 in the total number of freight locomotives on line compared with 1923.

Ideas of good performance have changed

On the whole, the extension of locomotive runs has greatly increased the average mileage per active locomotive. The extent of this increase, in most cases, has not been as pronounced as it should be, due to retaining too many classes or units of motive power in service. With proper attention as to assignment, selection and maintenance of the locomotive, it should be possible to materially increase the average monthly mileage over that made five or six years ago and on some divisions to practically double the mileage.

The committee finds instances of extended runs where all active locomotives in an assignment are regularly making 10,000 to 12,000 miles per month in passenger service and between 5,000 and 6,000 miles in freight service. Under these conditions, we find approximately 12 hours productive time per day and 12 hours non-productive time, the latter divided into eight hours mechanical time (time of arrival at the engine house until repairs are complete) and four hours transportation non-productive time.

Statistics for supervising utilization of locomotives

In addition to those statistics necessary to cover the general record, operating cost and performance of power, a daily turn-

ing power report should be kept for the benefit of local and division supervisors which will show the movement and distribution of the non-revenue time of freight locomotives at terminals. This report should be kept at all terminals by 24-hour periods, showing in detail the movement and time required for such a cycle from the time the locomotive arrives at the terminal with the train until it departs from the terminal with the train. Reports should be in sufficient detail to give the local officer a complete check on terminal time so that corrective measures may be taken to reduce this time in any respect that it is found excessive. This report will indicate whether or not movements to or from the yard, over the ash pit, repair time, waiting train time, etc., are reasonable, and total terminal delay may very often be materially reduced by following up such information.

A special study should be made of the idle time locomotives are awaiting trains and the locomotive assignment maintained so this time will not be excessive. A daily record and reports should also be kept of the locomotives undergoing or awaiting heavy running repairs, certificate repairs and other engines held out of service 24 hours or longer. By carefully checking such power, the time out of service for such repairs may be reduced, the attention of proper authorities forcibly drawn to the needs of forces or facilities to more promptly handle such repairs, or setting up other corrective measures to return this power to service more promptly.

It is important also that a daily or a weekly expected mileage for freight locomotives be determined for each division as a mark to attain. Low mileage should be analyzed to determine if there is too much power in service.

All such reports must, of course, be accurately prepared and constantly used by local and division authorities if they are to be of value.

Dispatching of locomotives and trains

Close co-operation must be obtained between the transportation and mechanical department forces so that delays to engines at terminals may be reduced to a minimum. The scheduling of trains at a time of day when the least interference will be encountered is a matter of vital importance. The dispatching of trains en route over the division must be given careful thought to avoid every unnecessary stop.

Telephone dispatching, the elimination of as many train orders as possible and every efficient dispatching means known should be employed to reduce stops and delays to the lowest possible minimum.

As far as possible, locomotives made ready at terminals and the dispatching of trains from the terminals should be anticipated, by at least the crew calling time, in order that the time between repairs completed and the time the engine leaves the terminal may be reduced to a minimum.

The anticipation of power is of importance both to the maintenance forces in scheduling repair work and to the transportation department in scheduling departure of trains.

The operation of all freight trains extra, eliminating time table schedules, unquestionably expedites the movement both with respect to departure from terminals as well as to road movement. The length of blocks, whether automatic, manual or manually controlled systems, should be studied with a view of obtaining the fullest utilization possible and with the least interference.

Prior classification, solid blocking of freight for certain destinations, etc., should be given careful consideration and these features carried out to the greatest extent possible, thereby materially reducing yard work and switching at intermediate terminals as well as to reduce switching at final terminal in disposing of cars. Many railroads are confronted with unnecessary stopping of trains at crossings which could be avoided if automatic signals were furnished, thus keeping away from the possibility of mechanical failures as well as delays incident to slowing down, stopping and accelerating trains, to say nothing of added tonnage which might be hauled if it were unnecessary to stop for crossings. In addition, where trains have to be consolidated the movement should be comprehensively studied with a view to co-ordination at meting points and dispatching, so as not to delay either motive power or cars unnecessarily.

It is thought that a study of the length of crew runs will reveal opportunities on many roads for an extension of the same, which, of course, should result in the elimination of unnecessary stops and delays to trains and, in many cases, to the lengthening of engine runs with the same crew.

A large part of the initial and final terminal delay is encountered in getting engines to and from the engine house and yard. The importance of reducing this delay to a minimum does not seem to be given the attention that it deserves. Close supervision of yard operation to eliminate lost time and delays to trains and locomotives arriving and leaving terminals is very important and tends to reduce delays to trains and lost engine hours.

Considerable improvement is in order at most yards in the utilization of yard locomotives. Apparently the full significance of lost time due to yard crews and engines working only a comparatively short part of their tour of duty is not appreciated by some yard organizations. At many yards where the operation is continuous, a great deal of saving may be accomplished by working engines of proper character 16 or 24 hours before being relieved and sent to the engine house, and in such cases, it is frequently economical to change engines in the yard by use of relief engines.

In the assembling of trains, consideration should be given to the importance of yard air testing plants where brakes are charged, tested and repairs made before outgoing engines arrive, in order to bring about a reduction in initial terminal delay. A competent and sufficient force of inspectors at dispatching terminals is essential in order to detect defects and make repairs prior to time train is scheduled to leave. A thorough inspection of all trains before the train is due to leave not only reduces initial terminal delay, but also eliminates the possibility of delays on road.

Tonnage ratings for locomotives should be established by the use of a dynamometer car or by careful practical tests. For the best results, it is, of course, essential that the locomotives be loaded, to the maximum rating consistent with grades, weather conditions, character of traffic, roadway facilities, etc.

Local freight trains as a rule do not handle as much tonnage as is possible to handle with the type and size of locomotive frequently used in this service and there is an opportunity for an economy by loading local freight trains heavier. By so doing, in many cases, the necessity of through freight trains having to set off or pick up cars at intermediate points between terminals will be eliminated. There is also an opportunity in many instances to use the locomotive assigned to local freight service for a tour of duty in the yard or as a helper engine during its period of lay-over at the terminal and thereby in some instances eliminating the need for an assigned yard engine.

It has become the practice to measure the performance on the gross ton mile basis. It does not follow, however, that the greatest gross ton miles per train hour or per locomotive per day or month reflect the most economical performance, unless the proper balance is established and carried out between tonnage and speed. A train of light tonnage, operating at high speed, may produce as many gross ton miles per train hour as a full tonnage train moving at slower speed. It is important that proper relation between speed and tonnage be maintained over each division consistent with track conditions and traffic conditions and requirements. Except over some districts where it is necessary, for traffic reasons, to move comparatively light tonnage trains at high speeds, the most economical performance will be obtained by handling the greatest tonnage possible over the division within the schedule time allowed before running into overtime.

Terminal facilities

Necessary terminal facilities are indispensable to prompt and thorough conditioning of locomotives and preparation for service. Special consideration should be given hot water boiler washing plants, engine-cleaning facilities, material storage and handling facilities; also the necessary crane and machine tool facilities dependent upon the nature or class of maintenance work to be handled at the engine house. It is very important that the storehouse and machine shop facilities be located either within or adjacent to the engine house proper. The following items of importance in an engine house layout should be given careful consideration:

Number and length of stalls.
Turn tables, proper length, power driven.
Proper heating and lighting, particularly natural daylight.
Firing up and blower systems.
Washout system.
Water lines.
Drop pit or drop table facilities.
Surface of engine house floors.
Smoke exhaust system.
Handling of work reports.
Power plant requirements.
Fuel and sand storage of sufficient capacity.

Your committee found considerable work being performed by both switch and road locomotives as a result of train yard facilities not being adequate for the volume of business handled. This results in additional yard time and expense in train preparation, as well as delays to road power. Adequate train yard facilities are necessary to secure the maximum work from each locomotive.

Locomotive repairs

Classified or general repairs should be made on a mileage basis. By reason of extended locomotive runs and greater utilization of locomotives, class repairs will come at shorter

periods of time, putting the locomotive into the shop where classified or extensive repairs may be made with less loss of time, at less cost to the locomotive and with improved condition of the locomotive during its term of service.

The committee's investigations indicate entirely too much loss of time for engines undergoing general or class repairs. It is extremely important in scheduling class repairs that a definite program be set up for at least three months ahead, and that care be exercised that locomotives are not bunched for shopping, either in total number or by class of engine or by class of repairs. Furthermore, when the locomotive reaches the three months period prior to shopping, careful inspection of engine should be made and all heavy or special materials that will be required be ordered.

Reduction in time necessary to make class repairs, as well as the fuller utilization of shop facilities, may be made in many shops by working two, or possibly three, tricks. At least a sufficient number of men should be placed upon second and third trick to do the stripping work on the locomotives, deliver parts for repairs and the completion of locomotives scheduled out.

For heavy running maintenance and monthly certificate repairs, as well as turn around repairs, best results are obtained by the monthly periodic inspection and repair method. At this time a thorough inspection and repair job should be done on the locomotive, putting it in condition to run to the next monthly period with a minimum of repair work and mechanical terminal delay, assigning repair forces where necessary so that this work may be carried on continuously throughout the 24 hours, thereby returning the locomotive to service with a minimum delay.

Every locomotive on a division or district should be assigned definitely to some terminal for maintenance and the responsibility for the condition of this locomotive to some designated officer.

The transportation officers are wholly responsible for getting the locomotive to the designated terminal on the date specified for monthly periodic attention, and it is vitally important that they co-operate with the mechanical department in this respect to obtain the best maintenance program. Furthermore, that between monthly inspection periods it is very important that transportation officers arrange to the greatest extent possible to have the long lay-over of power at the maintenance terminal, thus reducing the lay-over at the turn-around points to the minimum.

Considerable study is necessary in establishing extended locomotive runs which necessarily must give consideration to handling the maintenance work at points where it can be efficiently and promptly accomplished. On arranged service trains the schedule, to a large extent, governs the lay-over time at terminals, and it is important that this time be sufficient to make the necessary repairs without excessive transportation delay awaiting trains.

Influence of equipment failures other than locomotive failures

Delays in yards and on the line of road due to failures of car equipment, yard air line and testing plants, water facilities, signalling or interlocking facilities interfere with the fullest use of the locomotive. The car failures are by far the largest source of delays en route. Hot boxes, air brake failures, brake beam, truck and draft gear failures are altogether too numerous and frequently cause serious delays to trains getting over the road. It is, therefore, important that careful inspection be made of trains for car defects and that careful tests of brake equipment be made, particularly at dispatching terminals. With a properly organized inspection and repair force and with some small and properly located repair track facilities at such main dispatching terminals, many cars can be repaired promptly and continue through in trains that would otherwise be thrown out, resulting not only in delay to movement of car, but the whole train.

Locomotive design

The design of a locomotive in all its detailed parts has a very decided bearing upon the possibilities of its utilization. The locomotive, with all appurtenances, should be carefully designed for the service required and the best of material used, with the thought of eliminating to the greatest degree possible running repair cost and delays.

Water for locomotive use

The committee feels that the matter of water treatment should be carefully considered and proper treatment given, as this has an important bearing upon the hours of service obtained from the locomotive. Almost any expense required to obtain the best water for locomotive use is justified. On some divisions where bad water exists or heavy treatment of the water is necessary the blowing down of boilers on line of road and at terminals within reasonable limits proves of considerable value in the preventing of foaming, accumulation of sludge and other locomotive troubles incident to foaming conditions, which result in road delay.

Fuel for locomotives

It is the thought of this committee that the best performance from the fuel standpoint may be obtained by using the best grade of fuel available consistent with the cost. We feel, however, it is more important, and that better operation can be obtained as a whole, to use a uniform grade of fuel for a division, district or, if possible, for the entire road than by mixing various grades and qualities of fuel indiscriminately. While the uniform quality of coal used may be of low grade, better results can be obtained by using same and providing suitable grates and draft appliances than by using various quantities of coal in one territory.

The use of relatively low grade fuel or fuels high in ash does not in itself preclude the possibility of extended locomotive runs, as at crew changing terminals especially, provisions may and should be made for cleaning the fire and dumping ash pan where conditions make this necessary.

Economies to be effected

With a given assignment of power handling a given amount of business, an increase in the productive time of the locomotive naturally results in a corresponding decrease in the number of locomotives required.

The pooling of power is a sound economic principle and should be employed to the fullest extent by railroads on runs which, owing to inadequate roadside facilities, are not now in position to run through intermediate terminals. These terminals may be made "turn around" terminals and the monthly mileage greatly increased by reducing the lay-over to the minimum.

The observations of your committee convince us that improved operation and utilization of locomotives may be obtained on practically every road without the expenditure of heavy capital investment, and before heavy expenditures are made, the fullest use should be obtained of existing road and terminal facilities. The extension of locomotive runs in road service, the increasing of productive hours per day in yard service, the elimination, or at least partial elimination, of intermediate terminals and the consideration of the various phases of utilization touched upon in this report should be carefully studied, in order that the existing facilities may be utilized more nearly to their full capacity.

On roads or divisions where extended runs are not possible, considerable increase in productive time of locomotives and increase in miles per month may be obtained by establishing the maintenance point at terminals best equipped for maintenance and making the other terminals simply turn-around points.

The report is signed by the following representatives of the Operating Division: T. B. Hamilton, Pennsylvania; J. T. Gillick, Chicago, Milwaukee & St. Paul, and A. E. Ruffer, Erie. Those representing the Mechanical Division are W. H. Flynn, New York Central; O. S. Jackson, Union Pacific, and O. A. Garber, Missouri Pacific.

Discussion

The discussion of this report centered on the possibilities of extended locomotive runs. In establishing long runs, the condition of the locomotives, fuel and water facilities, the human element, lubrication and maintenance problems are some of the important factors that must receive due consideration. An interesting result of long runs was brought out by John Purcell (A. T. & S. F.) who stated that since the inauguration of long runs, flue, staybolt and boiler sheet failures have been practically cut in two, so far as the cost and number of failures are concerned. This was attributed to the fact that long runs greatly reduce the number of expansions and contractions customary with short runs. The type and the condition of the grates was mentioned by Silas Zwight (N.P.) as one of the most important factors aside from the condition of the firebox and flues.

T. W. Demarest (Pennsylvania) said that extended runs produce economy in two ways. If properly applied, they mean a reduction in capital and in running main-

tenance. The reduction in capital is only obtained if the number of engines performing the service are reduced. Otherwise the savings are a little in maintenance and coal. The establishing of one long engine run does not mean a saving of money, he said. There is only one thing that counts and that is the monthly production, either in mileage or in gross ton-miles hauled. If the amount of power is not reduced, if the gross ton-miles per locomotive per month is not increased, then there is nothing in the long engine run.

Engine condition is seriously affected by the number of times the fire is drawn and the steam pressure reduced. Mr. Demarest expressed the opinion that there is no reason, except for wear of parts, why an engine should not run indefinitely, and that the modern locomotive is reasonably well designed to run at least 1,000 miles.

The report was accepted.

A. G. Pack comments on splendid condition of power

By A. G. Pack

Chief inspector, Bureau of Locomotive Inspection, Interstate Commerce Commission

A. G. Pack

The beneficial effects derived through meetings of organizations and associations such as the Mechanical Division of the American Railway Association are recognized without question. The standards established and adopted by your organization are looked upon in the United States and Canada, and probably throughout the entire civilized world, as being of the greatest value along the lines of our endeavor—that of promoting safety, efficiency and economy of transportation of persons and property. The duty of this association, as set forth in the constitution of the A. R. A., is "To consider and report upon methods of construction, maintenance and service of rolling stock of railroads."

Your interest and mine are not unlike. I am particularly interested in safety—safe design, safe construction, safe repair, and safe operation. When this is accomplished it means that the principal source of transportation on the railroads—locomotives—is both efficient and economical, therefore, both go hand in hand.

The progress which you have made may be measured in various ways,—in dependability and speed of service, in cost per unit of transportation, in utilization and in reduction in defects which may result in accidents and serious delay to traffic. With such tremendous responsibilities resting upon your organization in meeting the demands of transportation, one directly responsible for the expenditures of such vast sums of money, one responsible to such a degree for the safety and efficiency of locomotive and car operation, and consequently the safety and efficiency of train operation, it is in my opinion not too much to expect that you be given broad powers in directing the affairs for which you are responsible. Not all of the operating officers have come to their positions with sufficient knowledge and intimate contact with the maintenance of motive power and cars to understand what they should be and what should be expected of them.

If the best results are to be obtained, the service must be rendered promptly and economically, but this cannot be accomplished if the equipment is not in condition to meet the requirements. A few cents per mile added to the necessary cost of maintenance is more than compensated for by the reduced cost of transportation, a basic fact too often overlooked. I know of no one who can estimate with any degree of accuracy the cost to the railroads and the traveling and shipping public of an engine failure or the serious delay to a train.

There is nothing which so adversely affects the economical maintenance of equipment as to disrupt the mechanical organizations at frequent intervals or to fluctuate its personnel with every temporary fluctuation in traffic. Equipment can not be properly and economically maintained if repairs are neglected until the busy season arrives. It is then that it should be in revenue service rather than on the repair track. It is then that the transportation department and the shippers are pressing for motive power and rolling equipment. Therefore, in keeping with good sound business principles, equipment should be repaired during dull periods and be available when rush periods come.

I appreciate that revenues cannot be disregarded in making expenditures, but I believe that with due consideration and foresight expenditures can be anticipated with sufficient accuracy to provide more uniform employment and practices than have heretofore been followed with respect to maintenance of equipment. The required amount of money must be provided and must be spent during the year, whether spasmodically or uniformly. The mechanical organizations of many of the railroads have been seriously embarrassed by being compelled to maintain modern equipment in obsolete shops with antiquated machinery, inadequate tools, insufficient material and material of inferior quality. It is true that there has been a great improvement in recent years in supplying larger shops, better roundhouses and better tools, but I am of the opinion that there is still room for much improvement along this line.

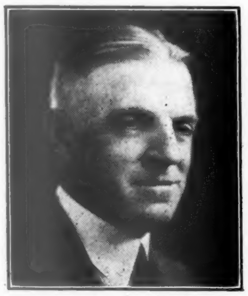
The government's rules are your rules. They represent what was in effect on the railroads prior to being adopted by the government, but not always complied with. If they had been, there never would have been a demand for the Locomotive Inspection Law. I am reminded by this of an incident which occurred soon after the original act and the rules and regulations established thereunder became effective. The general manager of one large system wrote to the then chief inspector that "if the government's rules were enforced, it would bankrupt every railroad in the United States." The chief inspector replied, making comparison with the rules in effect on his line prior to the adoption of the government's regulations, showing that his own rules were very much more stringent than the government's rules. When the same general manager replied, "There is a wide difference between a rule that may be varied from at will and one that becomes law and must be complied with." The failure of the railroads to comply with their own rules is what brought about the law.

The law gives the chief inspector of locomotives, with all of the inspectors appointed under the act, broad powers in seeing to it that the rules and standards adopted first by the railroads and later by the government are complied with. A law or rule that may be varied from at will according to the judgment of individuals interested, especially so when working under heavy pressure, becomes of little value. It has been too often said "She will make another trip" or "She came in and can go out." It is the next trip that causes the trouble. By proper co-operation and co-ordination of our duties the more punitive measures provided in the

law for its enforcement can and should generally be avoided, and I wish it were so that our inspectors would never find it necessary to report a defect on a locomotive, the repair of which had been neglected, or order a locomotive out of service for violation of the law or rules established thereunder. We are not seeking to make a record that will condemn any railroad or to show an inclination on its part to violate the established law, but we are earnestly striving to bring about the safest condition possible and to enhance the earning power of locomotives.

Locomotives throughout the United States during the last fiscal year ended June 30, 1926, were in better physical condition than I have ever before known them, and our records will indicate that during the fiscal year now coming to a close they are even in better shape than the year previous. The Bureau of Locomotive Inspection is getting better co-operation on the part of the railroad officers in the matter of complying with the law and rules than ever before existed, and I am proud of the cordial relations apparent.

M. J. Gormley discusses results of car efficiency



Underwood & Underwood

M. J. Gormley

In his address, M. J. Gormley, chairman, Car Service Division, showed how effectively the program of the railroads to provide adequate transportation service had been carried out, and discussed some future possibilities. His address is given below in abstract.

The Car Service Division, in reality, is employed to police the carrying out of the Car Service Rules, which are designed to return cars to the owning lines, either loaded or empty, in such volume as to meet the traffic requirements of the individual owning lines and insure the proper maintenance of the equipment.

Car distribution

We have three major problems of car distribution: The return of refrigerator equipment from the large consuming territories of the districts east of the Mississippi and north of the Ohio rivers to the producing territories of the west and south; the return to the western agricultural territory of the equipment that has been used in the transportation of agricultural products from the west to the large consuming territories of the east and south, and the return of coal car equipment to large coal producing lines from lines beyond the car owners' rails.

The population of the territory west of the Mississippi river is 17 people to the square mile, and east of the Mississippi and north of the Ohio is 156 to the square mile. Seventy-two per cent of the total grains and 72.5 per cent of the total animals and products are produced in the western district. On the other hand, 72.6 per cent of the manufacturing establishments, as measured by their capitalization, are located east of the Mississippi and north of the Ohio rivers. This densely populated eastern territory is a very large consumer of the agricultural products of the west and south. The heavier traffic, therefore, is constantly eastbound and northbound into this large manufacturing territory of the east and the lack of westbound and southbound traffic in equal amount makes necessary the continued return to these territories of empty equipment. Unless this equipment is moved regularly from day to day, either loaded or empty, congestion would very quickly result in the eastern territory, and with a shortage of equipment in the west and in the south.

Adequacy of transportation

The adoption by the railroads in 1923 of the "Program to Provide Adequate Transportation Service" is now well known to all. It has been carried out in its entirety and no doubt the results obtained are far beyond the fondest dreams of the railroads at the time of its adoption. The railroads recognize that adequacy of transportation at all times, regardless of conditions, is their duty.

During 1926 there were loaded 53,308,753 cars, the largest year's business ever handled by the railroads of this country. The average daily surplus of equipment during 1926 was 205,054 cars, and the lowest surplus, at the time of the heaviest loading, was 88,130 cars.

Efficiency in car handling

Miles per car per day have increased from 27.8 in 1923 to 30.4 in 1926. Tons per loaded car originated, averaged 34.5 in 1923 and 35.1 in 1926. The demurrage assessed, averaged over the number of loaded cars, excluding merchandise and l.c.l., amounted to 75 cents per car in 1923, and 56 cents per car in 1926.

The tonnage figures show, as to the items of coal, sand, stone and gravel alone, that the tons per car obtained in 1926 over 1923 was 1.7 tons. Had there been no increase in the tons loaded per car in 1926, compared with 1923, it would have required the handling of 396,000 additional cars to have moved the 1926 tonnage of these commodities. Furthermore, had there been no increase in tons per car in 1926 compared with 1920, it would have required the handling of 801,000 additional cars to have moved the 1926 tonnage.

The wheat loading in 1926 averaged 1.3 tons per car more than in 1920. Had there been no increase in tons per car, 1926 compared with 1920, it would have required the handling of 19,477 more cars to have moved the 1926 tonnage.

We believe the mechanical officers of the railroads can point with pride to their foresight and ability which brought about the more modern and efficient car which makes results such as these possible.

Possible results of car efficiency on car ownership

The addition of 608,777 modern, high capacity cars, either new or rebuilt; the retirement from service of 552,358 low capacity, inefficient cars; the placing in service of 11,049 locomotives since January 1, 1923; the co-operation of the shippers through the medium of the Regional Advisory Boards and the important part they have played in reducing the time required for loading and unloading of equipment, as indicated by the decreased demurrage assessments; and, to some extent, an increase in the loading per car, were the main factors that made it possible for the carriers to handle the greatest traffic in their history, and, at its peak, to have available a large surplus of equipment. A recent report of the Car Service Division, which has been approved by the Board of Directors of the American Railway Association, reads, in part, as follows:

After very careful consideration of this question of the economical use of cars, the Car Service Division believes that it is possible to handle the traffic of the country for some time to come with a total decrease in the ownership of open top and box cars of at least 100,000, provided:

(1) That there be a continuation of the replacement of the smaller capacity and less efficient cars with cars of modern type.

(2) That there be a continuation of the present plan of main-

taining equipment at the highest practicable point, as determined by the necessities on the individual railroads.

(3) That there be a further increase in the miles per car per day of at least one mile.

(4) That further intensive consideration of the load per car be given by railway management and all the Advisory Boards with a view of increasing tons per car to the greatest possible extent and not less than average of one ton per car.

(5) By careful supervision on the part of industries as to loading and unloading of equipment with a view of making a reduction of at least 20 per cent in the amount of demurrage assessed during the year 1926.

The Car Service Division recognizes that these conclusions as to car ownership would not apply to every individual railroad, there being without question some lines requiring a larger proportion of new equipment to meet their increasing traffic necessities than would be applicable to the lines as a whole.

This suggestion of the Car Service Division, if carried out, will be a complete fulfillment of the aims of the railroads, with the assistance and co-operation of the shippers, to handle an increased traffic with a decreased expense for overhead in car ownership.

We call the particular attention of the mechanical officers to the part which they should play in this proposed program of reducing the total ownership of equipment by replacement of the less efficient with more modern type equipment, and by maintenance of the equipment to the highest possible standard.

You will note that here, again, you are called upon to shoulder a major part of the problem. We are not unmindful of the fact that the replacing of obsolete equipment is not entirely within the control of the mechanical officers, but they certainly are in position to point out to their executive officers where they can make a good return upon the investment by retiring some of the older type and less efficient equipment. In other words, you must necessarily put yourselves in the same position with your own executive officers as the salesman who is selling you a machine tool, on the basis of proving to you that its purchase will bring about such a reduction in your operating and maintenance expenses as to justify the expenditure.

Empty car mileage

The very vital and important question of empty car mileage is receiving constant consideration and study by the individual railroads with a view of its reduction to the lowest possible minimum. One thing necessary on the part of any railroad in dealing with empty car mileage is to maintain such checks and records from day to day as will insure that there be no unnecessary movement of empty equipment in the direction of the preponderant loaded movement. We know that in the opposite direction there must be an empty movement, which is unavoidable. The principal causes of empty car mileage and its variation from year to year are largely due to things over which the railroads have no control.

If you will examine the records of your individual railroads you will see that the best records in the percentage of empty mileage have been made during periods of congestion, and coincident with that has been car shortage. Empty cars standing still do not make mileage, but they do cause car shortages. Generally speaking, when you have an increase in the miles per car per day, one period compared with another, it indicates a more prompt movement of all the empties, better service to the public, and also an increase in the percentage of empty mileage.

Capital expenditures and operating expenses

The addition of large numbers of modern cars and locomotives, heretofore referred to, in addition to improvements in terminals, reduction in grades, etc., has meant the expenditure of large sums of money to provide the adequate transportation service now being rendered. During the past six years the railroads have made an expenditure of $2,450,751,648 for equipment and $2,102,726,104 for other improvements, a total of $4,553,477,752. The other side of the story is that the operating expenses for 1926, when the heaviest traffic on record was handled, $1,112,600,000 less than 1920. True, this reduction was not all due to the improvements made in the physical plant but certainly the largest part of it was due to that fact. These results, to my mind, not only prove the wisdom of what the railroads have done to provide more adequate transportation but also point the way to what they must continue to do in the future to provide for the constantly growing traffic demands of the country.

Without the money to pay, a railroad, of course, is handicapped. It cannot buy equipment; it cannot maintain its road and equipment; it cannot secure the latest improvements; it cannot, in a word, adequately finance its operation. It goes without saying, therefore, that unless a railroad can earn a reasonable and safe margin above expenses, it is very definitely limited in its ability to furnish transportation service. We believe this is now fully understood by not only the governmental regulatory authorities, but also by the public.

There seems to be no question but that employees can be secured in ample numbers, and with training and ability to carry on railroad operations. There appears to be no limiting factor in this respect.

As to physical equipment, there will be no question, with financial ability to purchase, and with man power to operate.

The ability of a railroad to furnish transportation service may be modified by the shippers' capacity to load and to unload. To be an active element in the transportation machine for manufacturing transportation service, a car must move. If I asked you now to close your eyes and think of a freight car, I have no doubt that a vision would come to you of a car standing still and not in motion, but only a moving freight car actually manufactures transportation service. A car standing awaiting a load, or a loaded car standing awaiting to be unloaded are both an obstacle to the free movement. The greatly increased car efficiency in the past few years is due in a considerable measure to the very active co-operation of the shippers with the railroads through the Regional Advisory Boards. With the continuation of that co-operation and a better knowledge on the part of shippers and receivers of freight of their responsibility in bringing about a more economical operation, through better utilization of the plant available, and with the financial ability of the railroads assured, there need never be any question in the mind of anyone as to the ability of the railroads to meet the transportation demands of the future, regardless of what they may be.

Discussion

In the discussion that followed, it was pointed out by J. J. Tatum (B. & O.) that the Car Construction Committee had designed a hopper car which could be loaded with three pounds of revenue load to each pound of dead weight, which, if adopted, would aid materially in saving 100,000 cars in the railroad car equipment stock. G. E. Smart (Canadian National) remarked that Mr. Gormley's paper had brought out some of the things that the mechanical officers are endeavoring to do and that is, to maintain the modern car and do away with the obsolete car. On the basis that the maximum cost per year for maintaining a car is $150, then by

eliminating 100,000 cars, a total of $15,000,000 in maintenance expenses could be saved for the carriers.

Chairman Sillcox speaks on more intensive use of equipment

It is indeed a privilege for the Mechanical Division of the American Railway Association to be assembled in Montreal for the purpose of conducting its business and carry on its work of assisting in improving the general character and operation of the railway industry. The benefits to be derived from the work of this association, it is hoped, will be equally effective on Canadian and United States lines, since the membership is composed of railways operating in both countries.

We are today attending conventions to obtain new ideas for self improvement and we are endeavoring to

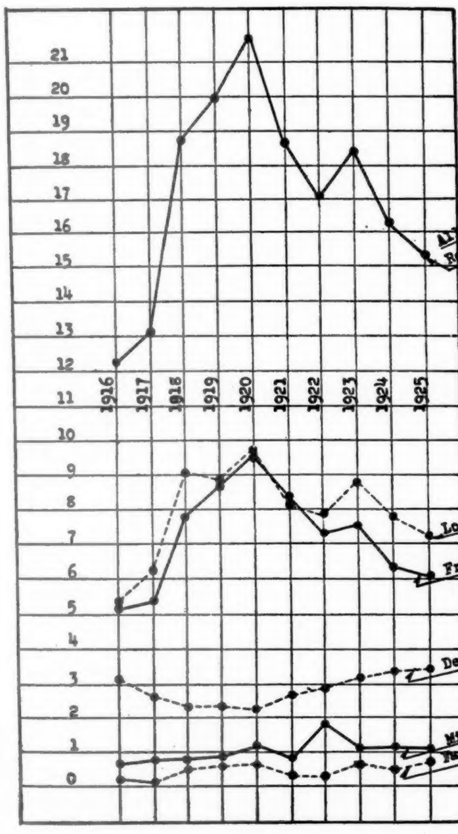


Chart C—Cost of maintenance of equipment in per cent of operating revenues

learn how to do better work in the future than in the past. The man who misses that point in a convention is disregarding the very reason for his attendance. We need to give due credit to the value of service rendered the railway industry by manufacturers of equipment and specialties and of the part they have contributed towards its upbuilding. In meeting conditions as they exist, at this time, we have much to do in the way of co-ordinating the use and adoption of new tools and devices with existing practices and plants in order to gain the greatest practical benefit for effective operation. Every precedent of the industry is subject to question in the light of changed conditions and the fact that we have always done something in a given way is a good reason for questioning that practice with a view towards improvement.

From the operating ratios and trends for Class I carriers in the United States it is apparent that the transportation expense ratio was 34.25 in 1926 and 32.60 in 1916, the difference still being 1.65. In the same way maintenance of equipment ratio was still 3.43 greater, maintenance of way 1.85 and all other expenses 0.65 greater than in 1916. The difference of 3.43 for maintenance of equipment is somewhat due to the difference of 0.3 in depreciation and retirement charges and these will not decrease for some years to come because of the price range of equipment acquired since 1916.

Trends in maintenance of equipment expenses

In the cost of maintaining equipment this may be divided roughly into (1) repairs, (2) depreciation and retirements, (3) miscellaneous such as superintendence, injuries to persons, stationery and printing, joint facilities, etc., and (4) repairs to facilities used for maintaining equipment.

This is illustrated by chart "C" in per cent of operating revenues. Repairs to rolling stock increased to a larger extent than charges for depreciation and retirements with a constantly increasing ratio for repairs to maintenance facilities due to lack of turnover and greater demand being made upon obsolete tools and power generating facilities than ever before. Locomotive and freight car repairs are shown separately on this chart to indicate to what extent they affected the total and this indicates that the proportion expended for freight car repairs has decreased more rapidly since 1921 than locomotive repairs due to a larger percentage of new units added in the case of freight cars as compared with locomotives. Passenger car repairs increased 33.8 per cent in ratio, the difference being that the ratio was 1.024 in 1916 and 1.370 in 1925.

In the case of freight locomotives the following shows the gross ton miles hauled and the relation of the locomotive ton mile to gross ton miles hauled:

	Billion gross ton-miles hauled	Billion net ton-miles hauled	Billion loco. ton-miles run	Per cent loco. ton-miles	
				To gross ton-miles hauled	To net ton-miles hauled
1921......	869	761	108	12.4	14.2
1922......	928	815	113	12.1	13.8
1923......	1,124	987	137	12.1	14.0
1924......	1,086	954	132	12.1	13.8
1925......	1,162	1,023	139	11.9	13.5
1926......	1,246	1,099	147	11.8	13.3

This shows that more work has been done by individual freight locomotives and that the gross ton-miles hauled per locomotive ton-mile, arrived at by deducting the net ton-miles from the gross ton-miles, including locomotive and tender to indicate the locomotive ton-miles, resulted in a lesser per cent of the total in 1926 than in 1921, or a reduction from 12.4 per cent to 11.8 per cent, a benefit of 5 per cent resulting. At the same time the per cent of locomotive ton-miles to net ton-miles decreased from 14.2 per cent to 13.3 per cent, a benefit of 6.3 per cent resulting. The gross ton-miles in 1926 were 43 per cent more than in 1921. The net ton-miles were 44 per cent more. It is thus apparent that the relation of net ton-miles carried to total train weight has improved. The locomotive ton-miles in this period increased only 36 per cent as compared with 43 per cent for total gross ton-miles, this being another way of expressing the greater efficiency obtained. The average miles run per locomotive per year decreased in the face of this improvement in performance, indicating the need for close study and positive methods to be applied in assisting still greater utilization of the transportation plant. The aggregate tractive force capacity of all classes of locomotives, that is, freight, passenger and switch, increased 10 per cent in the same period, which is less than the business increase.

It is interesting to note, in this connection, the cost per

locomotive mile for repairs, fuel and enginehouse expense from 1916 to 1925, inclusive, as shown in the following tabulation.

Cost per locomotive transportation service mile

	Repairs, cents	Fuel, cents	Enginehouse expense, cents
1916	11.43	14.56	3.02
1917	14.10	22.43	3.85
1918	25.74	29.46	6.94
1919	29.35	30.05	8.37
1920	35.01	39.69	10.03
1921	30.70	35.53	8.96
1922	29.25	34.11	8.21
1923	33.12	31.18	7.66
1924	28.89	27.00	7.30
1925	27.88	24.72	6.90
Per cent in 1925 over 1916	128	69	144

In this respect the cost per mile for fuel was 69 per cent greater in 1925 than in 1916, whereas the cost of enginehouse handling was 144 per cent greater, from which it is evident that improvement in roundhouse facilities and methods is an important issue for consideration. At the same time in this respect locomotive repairs were 128 per cent greater.

Enginehouse expense still high

Enginehouse expense has not decreased in cost as rapidly as it should, particularly in view of the fact that the increased utilization of power should reduce the frequency of enginehouse care in relation to mileage run. Terminal facilities are of the greatest importance in this respect. Improvements along this line may be considered from two viewpoints, one being the design and equipment of the enginehouse plant and the other being the number of roundhouses needed for a given service. In the latter case, it has been found that the average distance between roundhouses ranges from 60 miles on some lines to more than 100 miles on other lines and it is, at once, apparent that the cost of enginehouse expense, in relation to mileage run, will be high or low according to this general situation. In the other case, it is of great importance that track layouts be such as to reduce hostler service to a minimum since this is a rather large proportion of enginehouse expense. This applies to inbound and outbound tracks, ash pit location, coaling, watering and sanding facilities, turntable capacity, etc. Aside from these elements, the handling of cinders is also a large expense and devices for reducing labor cost are desirable. The cost of boiler washing is a particularly large element in this expense and water pressure, together with hot water facilities, determines the efficiency of this work, affects the cost and also affects the fuel performance in a measure. Hot water washout plants result in making roundhouse stalls available to a greater extent through speeding up the operations and also save locomotive fuel used in firing up. The installation of such facilities has added to the improvement in fuel performance in recent years. The indications are that enginehouse expense will eventually cost approximately 6 cents per mile or less until there is an increase in the number of new or rehabilitated pivotal terminal facilities provided for more efficiently handling locomotives when a further reduction in cost per mile may be expected.

Freight cars

Progress has been made in the design, maintenance cost and performance of freight train cars in the ten year period referred to. Car shortages have practically disappeared. At the same time the number of freight cars owned by Class I carriers increased only 4.7 per cent, but the aggregate carrying capacity increased 16.3 per cent while the average carrying capacity increased from 41.0 tons to 44.8 tons, or 9.2 per cent. The proportion of the total cars which are of steel construction, that is, all steel, steel framed or steel underframe, etc., increased from 57 per cent to 73 per cent.

The cost of maintenance increased from $83 per car to $156, or 88 per cent. The cost of maintenance per car mile increased from .81 cents to 1.39 cents, or 71 per cent and during this time the average miles run per car increased from 10,000 to 11,150, or 9 per cent. It has been shown that the maintenance cost of freight cars declined more rapidly than that of locomotives in the past five years and the conditions bringing this about differ considerably in the matter of policy. The life of a freight car is about two-thirds that of a locomotive; this at least has been the past experience. For that reason the renewal periods occur more frequently and obsolescence is a greater factor. The rate of turnover of freight cars has been found to be high on some railroads and where this has been consistent with what has been needed the maintenance cost has been reduced very materially. The following tabulation shows the per cent of total cars retired and acquired in each year for the past ten years and other elements which affected maintenance and performance:

	Average rate of turn over, per cent	Per cent cars of steel	Average carrying capacity in tons	Repair cost per car-year, dollars	Repair cost in cents per car-mile	Repair cost per aggr. ton capacity dollars	Ratio of repairs to oper. rev., per cent
1916	5.1	57	41.0	83	.81	2.06	5.288
1917	3.8	61	41.5	97	.93	2.28	5.414
1918	2.9	61	41.6	164	1.70	4.00	7.927
1919	2.9	62	41.9	186	2.08	4.50	8.700
1920	2.3	65	42.4	252	2.54	6.04	9.574
1921	2.8	66	42.5	199	2.29	4.71	8.457
1922	4.9	67	43.1	176	1.90	4.12	7.300
1923	9.2	71	43.8	204	1.85	4.70	7.560
1924	5.8	73	44.3	160	1.52	3.66	6.433
1925	5.3	73	44.8	156	1.39	3.52	6.097
Per cent over 1916		29	9.2	88	71	70	15

These trends are illustrated on chart "F" which indicates that the turnover has affected the cost of repairs in that the cars of wooden construction have been retired very largely since 1922. The characteristics of turnover trends will change somewhat as the proportion of cars of steel construction become larger, as this may increase the average life, provided current repairs are adequately maintained.

The effect of car construction and maintenance on train performance is shown in the following tabulation as to gross tons per train, excluding locomotive and tender, net tons per train and the resultant weight of cars per train:

	Gross tons per train	Net tons per train	Car. wt. per train	Per cent net	Per cent car wt.	Frt. ton-miles per loaded car mile
1921	1,435	651	784	45.3	54.7	34.2
1922	1,466	676	790	46.1	53.9	39.7
1923	1,539	713	826	46.3	53.7	40.3
1924	1,588	715	873	45.0	55.0	44.3
1925	1,620	744	876	45.9	54.1	44.4
1926	1,737	772	965	44.4	55.6	...
Increase	21 per cent	18 per cent	23 per cent			

This shows that the per cent of car weight to total train load has been increasing and the per cent of net load carried has been decreasing and that the question of car construction in relation to dead weight is before us to a marked degree. It is necessary to await the results of the future to determine whether the question of car weight and design is going to result in a cheaper transportation cost from this viewpoint. We are, nevertheless, faced with the fact that in this period gross tons per train increased 21 per cent, while net tons per train increased only 18 per cent and at the same time car weight increased 23 per cent. Much has been said about obtaining greater loading per car, but this is a traffic problem and we have been concerned with the car strength in relation to train performance with the hope that the average load per car would increase in proportion and

thus compensate for the work which it has been necessary to do to operate larger trains with greater reliability of movement. The strengthening of cars has been a contributing factor in the reduction of transportation expense, even though the average load may not have increased the earnings per car as desired. The load factor has not increased with the load carrying capacity, but the

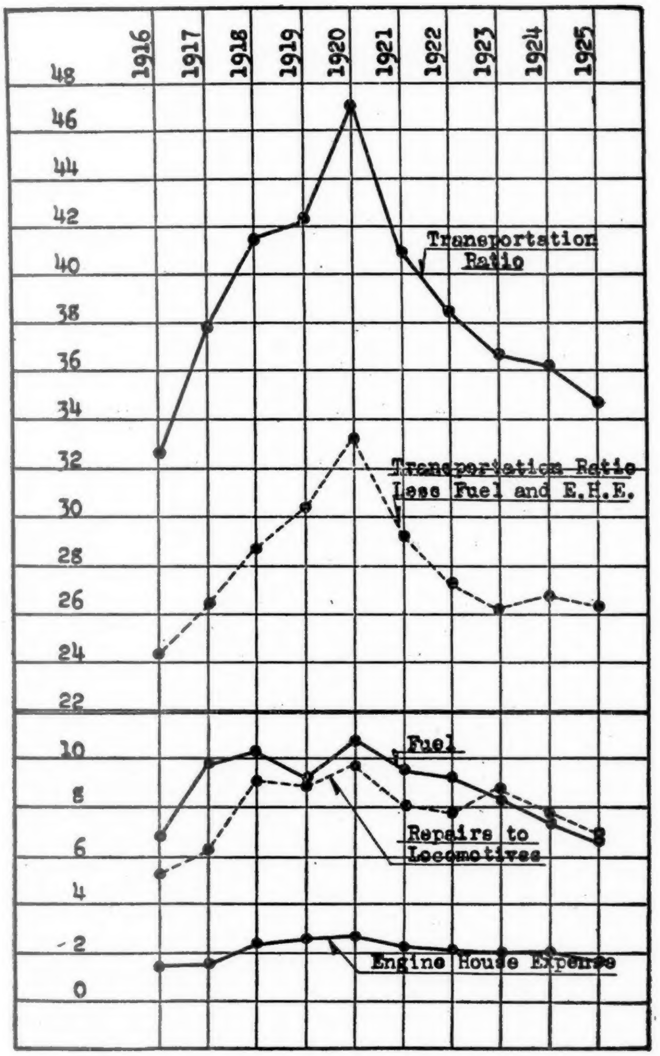


Chart D—Transportation, fuel, enginehouse expense and locomotive repair cost ratios

net ton-miles per freight car mile increased approximately 30 per cent in the latter portion of this period.

In the matter of freight car maintenance much can be done in classifying freight equipment by age, character of construction, frequency of heavy repair work, etc., so as to bring about heavy repairs in a balanced manner. A study of the relation of light repairs to heavy repairs develops the fact that with a given ownership the character of construction will lend itself to a rather definite period of reconditioning. Progress along this line can be made to a considerable extent, but it involves the regulation of shop forces as between light and heavy work to permit of establishing more definite plans for providing facilities of proper capacity. While this has been worked out in a general way, much can be done to concentrate heavy freight car repairs and reduce the cost by reason of volume handled somewhat similar to the back shop arrangement for locomotives. Any attempt to do heavy repair work at light repair points will naturally increase the cost of such work.

The number of passenger train cars owned by Class I carriers increased only 4.8 per cent in the past ten years. The character of ownership as to types of cars shows that the number of coaches increased only 0.4 per cent, dining cars increased 8 per cent, baggage cars increased 29 per cent and miscellaneous types increased 14 per cent in this period, but combination cars remained practically the same, and there was a decrease in the number of railroad owned emigrant, parlor, sleeper and postal cars. The number of cars of steel construction was 32 per cent of the total in 1916 and this increased to 51 per cent in 1925.

With the increase in the number of steel constructed cars, there has been practically no appreciable decrease in maintenance cost, and we are, therefore, confronted with the problem of further improving the character of mate-

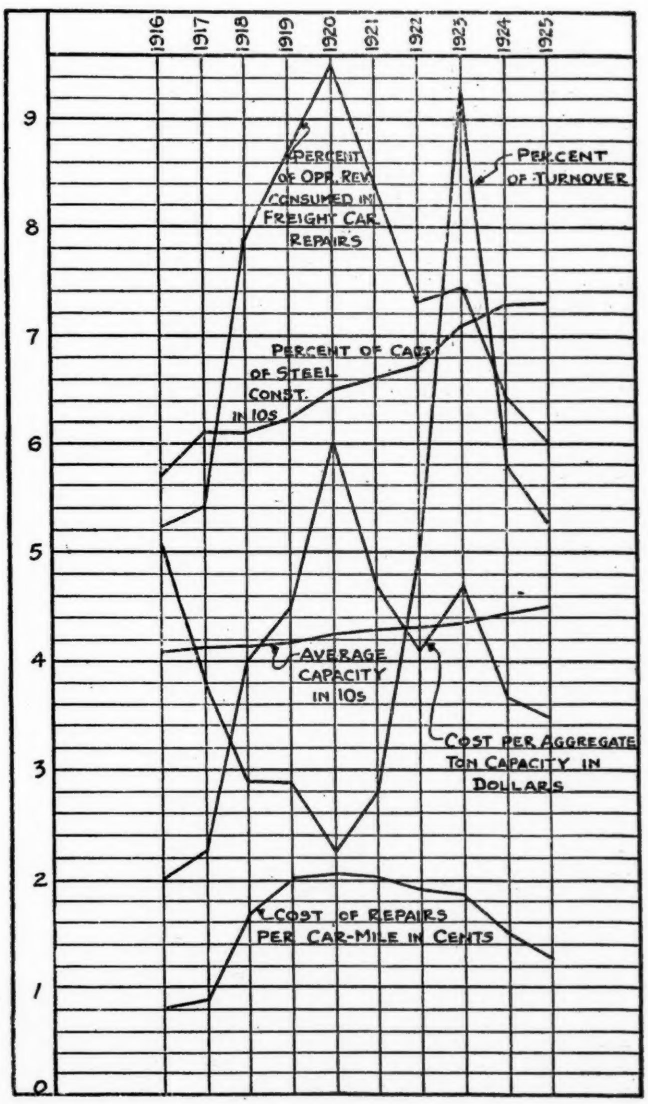


Chart F—Trend of freight car repair costs, turnover and construction

rials used so as to reduce the heavy repair frequency. The major portion of repairs to passenger cars is heavy repairs, and in this respect passenger car maintenance differs in character from that of locomotives and freight cars. That being the case, the question of passenger car designs and material is very important and should be given careful study.

Very little, if any, improvement has been made in the character of repair facilities to handle passenger car

work. It would seem well worth while to have this matter studied for the general good, and each carrier can well afford to go into this question very fully. The efforts along this line will be well worth while and should be made so as to bring the relative cost of maintenance of passenger cars to a more satisfactory basis. In certain sections, due to competitive conditions, the proper upkeep of passenger train cars is almost a first call upon management, because where passenger service is not maintained upon a high level, in such circumstances, the railroad may fail largely in attracting an adequate proportion of freight business and no members of the railroad family have to bear this urge more peculiarly than do the mechanical officers, thus adding to their expenses for the good of the railroads as a whole, being in substance a form of public contact.

Summary

The year 1916 was taken merely as a matter of a ten year comparison and that year in itself was no particular criterion. However, we are interested in the actual cost of repairs and the relation of the cost of maintenance and operation to operating revenue. When using the latter as the basis, it has been found that locomotive repairs consumed 36.8 per cent more of every dollar earned in 1925 than in 1916, passenger car repairs consumed 33.7 per cent, freight car repairs 15.3 per cent, enginehouse expense 28.1 per cent and transportation expense 7.1 per cent, with a decrease of 4.7 per cent in the cost of fuel.

Locomotive repair costs can be reduced by owning and maintaining only a sufficient number for the business handled and having large locomotives and maximum utilization in freight service consistent with a balance between transportation expense as to trainmen, repairs, enginehouse expense and fuel consumption; and having maximum utilization of passenger power with as small a number of units as is consistent with the business and of a size not too large for the capacity of the trains handled.

Passenger train car repair costs can be reduced by improving materials and design with a view to obtaining greater service between heavy repairs and at the same time increasing the mileage performance by better utilization so as to keep to a minimum the number needed for the service.

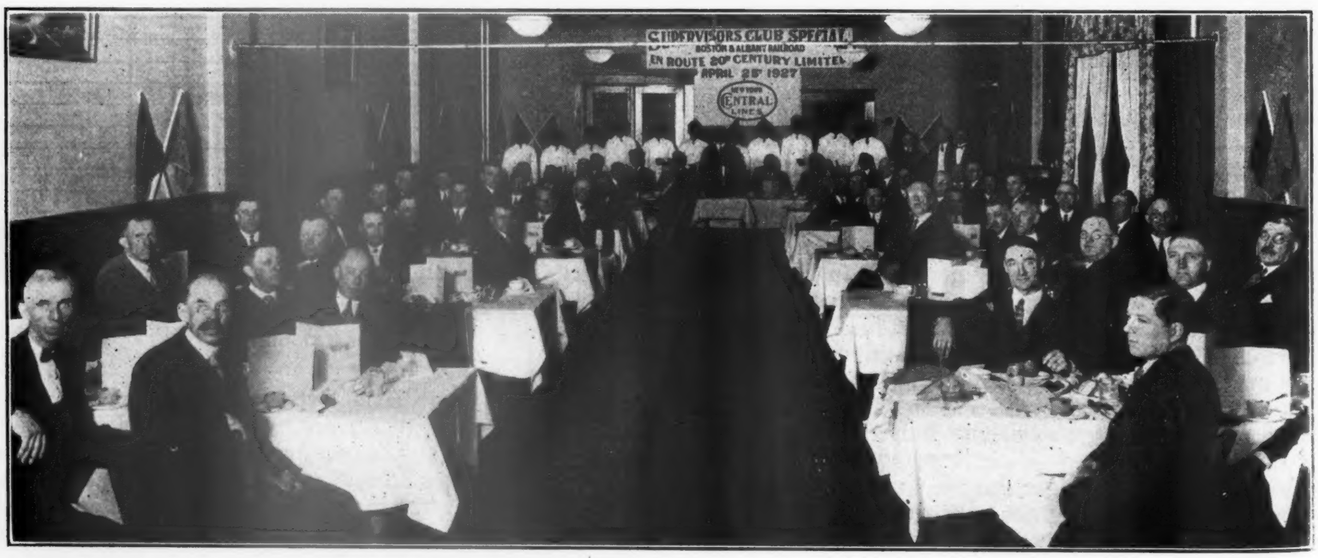
Freight train car repairs can be reduced by more systematic attention, maximum utilization and proper construction. Questions of design are being given careful consideration by this association and work along this line has shown marked results. Repair costs are affected by the number of cars maintained and it is imperative that the number be reduced to actual requirements. It is possible to obtain greater utilization of freight cars because the mileage run per car per year is still too low. Giving cars major repairs at proper intervals to avoid running them beyond the major repair period, systematizing heavy repair work and reducing the amount of damage to cars in trains and yards as well as by shippers should result in reducing the cost.

Enginehouse expense can be reduced by operating only those terminals which are actually needed, accomplished by increasing the length of runs and by improving terminal facilities actually required.

Doubtless, further savings in fuel cost will be made in the future by increasing the locomotive performance and decreasing the turnings in relation to the mileage run.

Transportation expense has a considerable bearing upon maintenance expense as the two are more or less related. The utilization of power and cars can be increased and while this may mean larger and fewer trains, the question of balancing the savings from such operation with what may be incurred in train and engine crew overtime as compared with running lighter and more trains to reduce overtime of trainmen is one that, if solved, should reduce transportation cost accordingly in relation to equipment performance.

Much remains to be done by this and other railroad associations in the matter of improving operating and maintenance conditions. The unit rate of revenues and the revenue volume do not fluctuate uniformly with the unit rate of expense and consequent expense volume, but the work of improving the performance and reducing the cost will constantly remain before us and efforts along such lines are laudable.



Boston & Albany Supervisors' Club held its last meeting of the season in the R. R. Y. M. C. A. at West Springfield, Mass., April 25

Brakes and brake equipment

Substantial progress being made with the power brake tests at Purdue—Slid flat wheels discussed by Committee on Brakes

TWO reports pertaining to the general subject of brakes and brake equipment were presented at the annual meeting of the Mechanical Division, American Railway Association, which was held at Montreal, June 7 to 10, inclusive. H. A. Johnson, director of research in charge of the power brake investigation at Purdue University, reported that substantial progress was being made in the investigation of power brakes and appliances for operating power brake systems. These tests have now been going on for over a year, during which time more than 600 tests have been run on various portions of both the Westinghouse and Automatic Straight Air Brake Companies' equipment.

The feature of the report of the Committee on Brakes and Brake Equipment was undoubtedly the proposed methods of avoiding slid flat wheels. That portion of the committee's report was handled in a separate paper, an abstract of which is included in the abstract of the report.

Report on safety appliances

By H. A. Johnson

Director of research in charge of power brake investigation Purdue University

Underwood & Underwood

H. A. Johnson

The investigation of power brakes and appliances for operating power brake systems has been carried forward during the year and the director of research is able to report substantial progress. The 1926 report covered the reasons for the investigation; the agreement to a general plan of procedure by the committee on Safety Appliances of the Mechanical Division of the A. R. A. and the Bureau of Safety of the I. C. C.; the appointment of a director of research; the reconstruction of the A. R. A. test rack at Purdue University, including the development and building of new test instruments; the placing of orders with the Automatic Straight Air Brake Company and the Westinghouse Air Brake Company for 150 sets of freight train air brake equipments which will meet the tentative specifications and the I. C. C. requirements; the preparing of a schedule of tests which was agreed to by the interested parties; the building up of an organization of trained men to carry on the work.

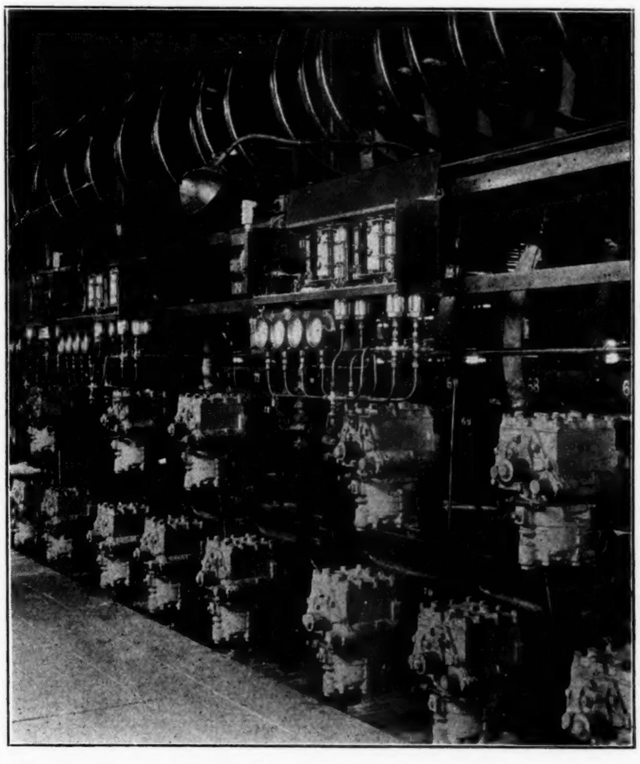
The test rack was first equipped with new standard Westinghouse type K triple valves. The tests on these valves started on November 30, 1925, and were completed on June 30, 1926. During this time more than 600 tests were run and it was necessary to stop the tests three times for cleaning and lubrication of the triple valves. Upon the completion of the tests, the type K equipments were entirely removed from the test rack and the Automatic Straight Air Brake Company's equipments installed. These equipments had been received at Purdue University about April 1, 1926. The equipments purchased from the Westinghouse Air Brake Company were received July 1, 1926.

After the installation of the A. S. A. equipments was completed, the test rack was turned over to the representatives of this company and they made such preliminary tests as they deemed necessary to satisfy themselves that their equipments were in proper condition and were ready for the official tests. The tests on this equipment started on August 17, 1926, and are still in progress. This equipment has been submitted to more than 600 tests, including single triple valve tests, 100-car train tests representing level road conditions, 100-car train tests representing grade conditions and 50-car train tests representing grade conditions. Since starting the tests on the A. S. A. equipments, it has been necessary to stop three times to clean and lubricate or make adjustments of the mechanism.

The Automatic Straight Air Brake Company claims that their equipment is superior to the Westinghouse type K equipment and possesses the following new functions:

1—That only a service application of the train brakes will occur when a service reduction of brake pipe pressure is made.
2—The ability to obtain effective emergency brake cylinder pressures after a full service application or after release following a full service application of the brakes.
3—The ability to maintain brake cylinder pressure against ordinary leakage.
4—The ability of the engineman to control the release of pressure from brake cylinders and effect such release by graduated steps in order that he may decrease as well as increase brake cylinder pressures as required to control at relatively uniform rates the speed of trains.

The series of tests with all cars in the train equipped with the Automatic Straight Air Brake Company's equipments will be completed during the first half of April, 1927.



Test rack at Purdue University equipped with automatic straight air brakes

Following this the A. S. A. equipments will be removed from 50 of the 100 cars and the Westinghouse standard K equipments replaced on these 50 cars so that 50 cars of the 100 car train will be equipped with A. S. A. equipment and the remaining 50 cars of the 100 car train will be equipped with Westinghouse type K equipment. In the first half of the train, the two kinds of equipments will be alternated every five cars and in the last half of the train they will be alternated every 25 cars. When the test rack has been set up in this manner, a series of tests will be made for the purpose of showing the effect of each type of equipment upon the other, or, in other words, to determine if the Automatic Straight Air Brake Company's equipments will operate harmoniously with the type K equipments in the same train. It is obvious that a new air brake

equipment could not be adopted for freight cars in interchange unless it was designed so that it would function satisfactorily when operated in the same train with the standard air brake equipment.

The Westinghouse Air Brake Company has submitted for trial two new air brake equipments; one of which, it is claimed, complies with the tentative requirements and specifications of the Interstate Commerce Commission as stated in its preliminary report and conclusions dated July 18, 1924, and the other equipment contains the ideas of the Westinghouse Company on the desirable functions of an air brake equipment for long freight trains. After the completion of the tests on the A. S. A. equipment, the two new Westinghouse equipments will be placed upon the test rack in turn and submitted to the same series of tests as the A. S. A. equipments, including the tests to determine whether these equipments will operate harmoniously with the present standard type K equipments.

Two inspection days have been held during the conduct of this investigation when all the members of the Mechanical Division of the A. R. A. were requested to send representatives to witness the performance of the brake equipments upon the rack and to become acquainted with the method of carrying on this investigation. The first inspection day was May 12, 1926, when the standard type K equipments were on the test rack. The second inspection day was November 12, 1926, when 150 men representing 65 different railroads and 10 other companies and associations observed the operation of the A. S. A. equipments on the rack representing a 100-car train.

During the year the research organization has been considerably increased. The results are being calculated and tabulated as the tests proceed. One part of the organization runs the tests and the other part of the organization works up the results. The tabulation and analyzation of the vast amount of information from the trainagraph records has proved to be a large task. The organization now comprises 70 men; approximately three-fourths are engaged in working up the records and one-fourth engaged in carrying on the test work in the laboratory.

Purdue University is doing a large amount of engineering and agricultural extension work which brings many meetings of associations and many visitors to the University. These visitors are from all walks of life, representing farmers' organizations, industrial organizations, bankers and business men. All of these delegations visit the air brake research laboratory and are greatly impressed with the work being carried on by the Association in the interest of greater safety and reliability of train operation. This publicity is very far reaching in the building up of good will toward the railroads. The Bureau of Safety of the Interstate Commerce Commission has maintained from one to three representatives at Purdue University since the air brake tests started and these representatives make daily reports to the Director of the Bureau of Safety, keeping him in constant touch with the progress and the results being obtained. Similarly, the Automatic Straight Air Brake Company and the Westinghouse Air Brake Company have their representatives present at all times and they also make daily reports to their companies on the work accomplished.

An invitation is again extended to all railroad men to visit the power brake laboratory at any time.

Report on brakes and brake equipment

G. H. Wood
Chairman

The committee has the following to submit for consideration:

Freight car retaining valve

Your committee recommends a modification in the specifications submitted on page 5 of last year's report covering the standard freight car retaining valve. Change the last four lines to read:

> With 8 in. piston travel or a volume of 640 cu. in., from 55 lbs. to 25 lbs. in 81 to 99 sec. when in high pressure position, and from 45 to 55 sec. when in low pressure position, should be used.

This changes the blow down time in high pressure position, which is at present specified as 85 to 95 sec. The change is requested in order that the same time tolerance will be provided for the high and low pressure valves, and to reduce the cost of manufacture and maintenance.

Air brake hose couplings and nipples

Some variation has been found in dimensions of air brake hose nipples, and we believe a specification for dimensions is warranted; means should also be provided to identify hose couplings manufactured in accordance with gages adopted last year, and to this end recommend the adoption of the drawing covering these features.

One-half inch common nut for triple valve bolts

Triple valve bolts received from the manufacturers are equipped with the A. R. A. standard ½-in. finished nut; however, it is the practice of the railroads to substitute the common ½-in. nut in making repairs. Your committee has been requested to recommend the ½-in. common nut as standard for triple valve bolts to avoid the necessity of repairmen using two wrenches. We have investigated and find that not enough care is used in the manufacture of the common cold punched nut, and that

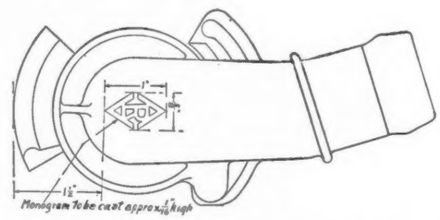


Fig. 1—Location of designating monogram on air brake hose couplings made to A. R. A. standard gages

difficulty in variation of sizes as between the finished nut and common nut would not be overcome by the general use of the common nut. The committee calls attention to this, urging more care on the part of repair points in maintaining the ½-in. finished nut in triple valve repairs.

Single car brake testing device

The committee has been requested to specify a single car testing device for testing brake equipment on freight cars in accordance with A. R. A. Maintenance Rules 101 and 102 as adopted in 1925. For the purpose two types of testing devices are shown, either of which will meet requirements. Heretofore various devices have been employed, some of them being far from satisfactory. The testing device, Figure 3, is finding favor on many roads. We would recommend the adoption of single-

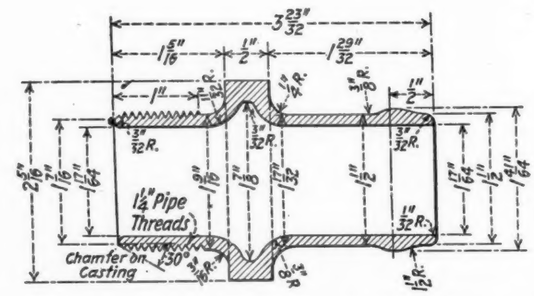


Fig. 2—Proposed standard A. R. A. hose nipple, 1⅜ in. by 1¼ in.

car testing devices as shown in Figs. 3 and 4, leaving it optional as to which particular device may be used.

Triple valve test racks

We have also considered a suggestion to require the use of a leakage indicator in connection with the present standard A. R. A. triple valve test rack. Many of these devices are in use on a number of roads and are apparently proving satisfactory, inasmuch as they provide for more uniform regulation of slide valve leakage, elimination of excess leakage due to poor judgment in the use of soap-suds, definite limitations of slide valve leakage, reduced compressor labor on account of lessened brake system leakage, less liability of brake cylinder pressure equalizing that of the auxiliary reservoir on partial service brake applications. This question has been considered in connection with a suggestion to prohibit the use of the 2-T test rack for testing freight triple valves. The committee agrees that there might be some merit in the latter suggestion although we recognize the fact that there are a considerable number of 2-T test racks still in service. We will attempt to learn to what extent the 2-T

racks are still in use and may later recommend some action looking toward the elimination of this type and standardizing on the 3-T type; in which event the leakage indicator will be considered in connection with this recommendation.

Tolerances for camber of brake beams

There has been some question regarding the proper camber of brake beams, the present recommended practice beam showing no tolerance for this measurement. In investigating we find that a variation in the camber in a brake beam within reasonable limits will in no way affect the strength or service of the beam. Brake beams have been built with camber as low as 1/4 in. and

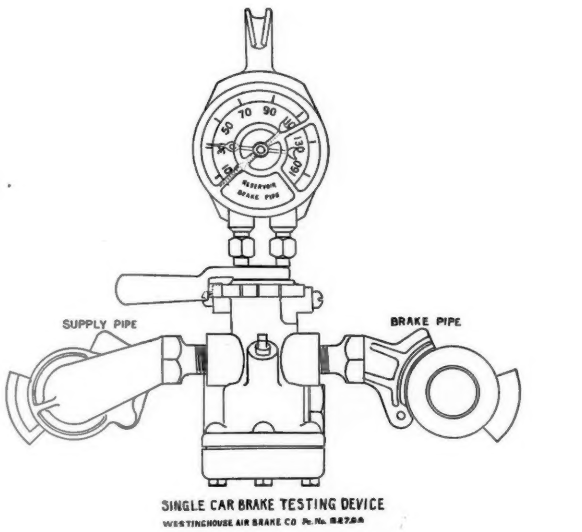


Fig. 3—Westinghouse single-car brake testing device

as high as 2 3/8 in. to meet the varying truck and brake beam clearance conditions, and all are giving satisfactory service.

It has been suggested that a tolerance of 1/8 in. plus or minus be provided for brake beam camber. In view, however, of the wide variation in beams now in service we feel that more consideration should be given the subject before recommending any change, as this might affect beams which are giving satisfactory results in service and bring about unnecessary expense. This matter will, therefore, be given further consideration.

Methods of avoiding slid flat wheels

Under subjects for discussion the committee was given the subject of Methods of Avoiding Slid Flat Wheels, the question to be covered as a special item. A paper dealing with the subject has therefore been prepared for your consideration. This follows.

On account of the limited time available for gathering data, we have been unable to develop the generally accepted methods in vogue or any particularly new methods which might be more advantageous in avoiding slid flat wheels; therefore, what follows is based upon experience upon the lines represented by the members of the committee.

Obviously, adequate maintenance of brake equipment is necessary if proper brake performance commensurate with operating conditions is to be expected. As a means of providing for adequate maintenance of brakes, we refer you to the present A. R. A. Maintenance of Brake and Train Air Signal Equipment Rules. A proper compliance therewith, both for cars and locomotives, will, we feel, avoid, as far as possible, slid flat wheels which might be contributed to by methods of maintenance which are less rigid in their requirements. It is of the utmost importance that the brake system be as free from leakage as possible in order that brakes having once been applied may, under proper methods of manipulation by the engineer, be released. The present A. R. A. Rules contemplate a maximum of 7 lb. per minute brake pipe leakage; however, this leakage should be maintained to a lesser degree insofar as possible. This, we feel, can best be cared for by a proper installation of pipe and fittings which are suitably and substantially clamped in position to prevent shifting and vibration, and by eliminating leakage from the brake system when cars are on regularly designated repair tracks or on other tracks where men and facilities are available for making suitable tests and repairs.

Care should be exercised in designing foundation brake gear to provide ample clearance and freedom of movement for all brake rods, levers, beams, etc., and that the angle of brake rods be as nearly as possible within the lines of force acting through their various connections. Brake beam hangers should be of proper length and position between their fulcrum point and the brake head to prevent increases in force on the brake shoe due to a wedging or togging effect, and we suggest the application of clasp type brake gear where conditions permit.

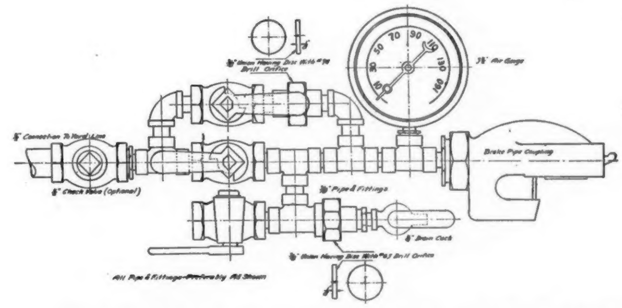


Fig. 4—General arrangement of single-car brake testing device

The committee has made no attempt to deal with this subject by outlining a detailed policy of instruction on manipulation or maintenance as we believe practically all roads have provided rules covering these features, but wish to call attention to a policy of checking and accounting which we think would justify consideration where such method is not the practice and the number of flat wheels occurring seems to be excessive.

The causes for wheel sliding are numerous and the conditions under which they occur are such that it is impossible, in all cases, for those supervising train operation to determine definitely the exact cause or circumstance under which they occur. Investigation will develop that on 50 per cent or more of cars having flat wheels tests of the brake equipment do not disclose defects which contribute to this damage. It is apparent from this that in

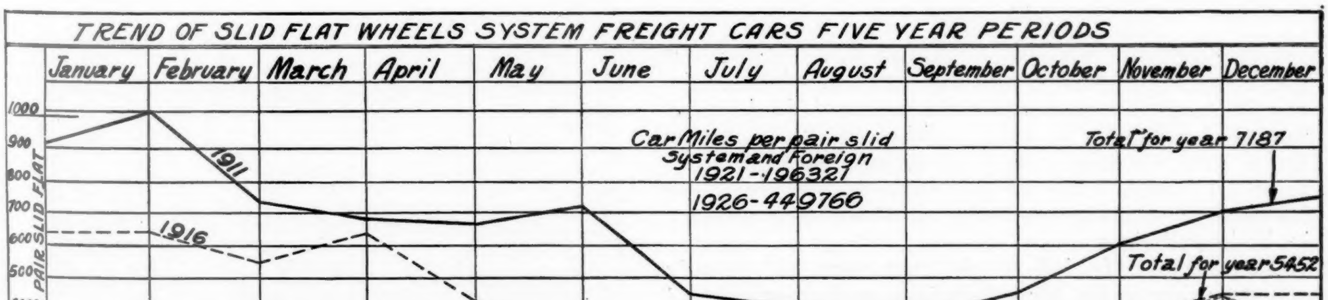


Fig. 5—Reduction in slid flat wheels obtained through method of checking outlined in committee report

ordinary operation many wheels are slid flat due to unavoidable causes or improper handling of equipments by trainmen and enginemen. The problem is one that the mechanical department cannot alone successfully cope with; it is necessary, therefore, that they have the continued co-operation of the operating department if the cost and delay incident to slid flat wheels is to be maintained at a minimum consistent with the operating conditions on any railway.

The following practice, we believe, approaches closely such a policy: Reports covering each case of slid flat wheels removed are forwarded directly to a designated mechanical officer with copies to the division master mechanic and trainmaster, this report to indicate the result of tests of the brake equipment upon such cars in order that any defective conditions found might be considered in connection with contributing causes. The report should show brake lever measurements for the complete foundation brake gear in addition to a complete test of the triple valve, brake cylinder and retaining valve, the previous cleaning date, the engine number handling the train, the name of the conductor, and engineman, and from what division the car was received. From such reports monthly summaries are made for each division of the system showing the total number of slid flat wheels removed compared to previous periods, and also the total number of cases chargeable to defective brake equipments such as triple valves, retainers or foundation brake gear. These summaries are reported monthly, quarterly, semi-annually, and annually, copies of the reports being forwarded to the general transportation and mechanical officers, such as general managers and superintendents of motive power, and also all local division transportation and mechanical officers, including the trainmasters, road foremen of engines, and car foremen.

These reports are scrutinized regularly by the general officers who call upon the local division officers for explanations regarding increases in wheel damage or where there appears to be an excessive number of slid flat wheels occurring over other divisions having similar operating conditions. The local division officers investigate cases of slid flat wheels as indicated by the reports rendered when the wheels are removed, calling the trainmen and enginemen to account for those cases which happened while the train was in their charge. Conductors are required to report flat wheels on cars picked up en route or which are in their trains when leaving initial stations. Inspection must be made as freight trains are leaving initial stations to check for slid flat wheels in the train at that time, and also when cars are picked up en route, otherwise trainmen and enginemen are charged with the responsibility for the damage occurring.

The local mechanical and operating department supervisors follow up the operating and maintenance conditions as reflected by these reports to bring about such corrective measures as are possible and practical. The results of this method having been established are graphically represented in Fig. 50.

This improvement has been continuous throughout a period of increasing weight and tractive force of locomotives, weight and length of trains and greatly increased car mileage. Possibly it is the predominating factor which makes for improved maintenance of equipment and train operation to bring about prevention of slid flat wheels.

This report is signed by G. H. Wood (chairman), Atchison, Topeka & Santa Fe; T. L. Burton, New York Central; B. P. Flory, New York, Ontario & Western; J. M. Henry, Pennsylvania; M. A. Kinney, Hocking Valley; W. H. Clegg, Canadian National Railways; Mark Purcell, Northern Pacific; R. B. Rasbridge, Philadelphia & Reading; G. E. Terwilliger, New York, New Haven & Hartford, and W. J. O'Neill, Denver, Rio Grande & Western.

Discussion

In presenting the report, Chairman Wood stated that the committee wished to substitute the following for the first item in the report under the sub-head, Freight car retaining valve: "A three-position 10-20-lb. duplex spring type retaining valve having nominal blow-down values of 50 sec. in the 10-lb. position and 90 sec. in the 20-lb. position should be used with both 8-in. and 10-in. brake cylinders."

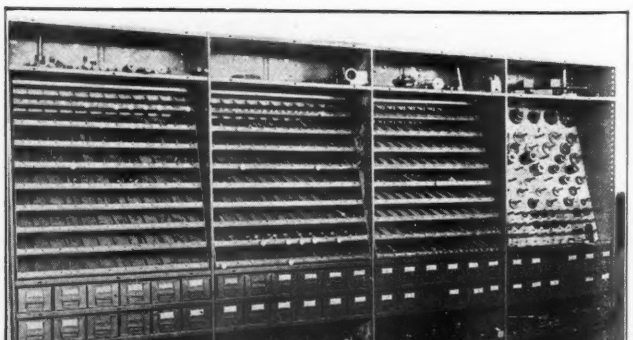
That means, Mr. Wood said, that there will be only one retaining valve for all freight equipment instead of about 15 types as at present and it will give an opportunity to recommend final tolerances for blow-downs which will not need further change.

A part of the discussion was devoted to the conversion of the 2-T test rack into a 3-T. Mr. Wood speaking for the committee said that most of the railroads are converting the 2-T test racks whenever they find it necessary to make repairs to them of any consequence. The committee thought that the railroads should have an opportunity to wear out the 2-T test racks that they have and probably by next year it will be ready to recommend their elimination.

A question was raised by E. Von Bergen (I. C.) relative to the A. R. A. standard ½-in. hexagon nuts used on the cylinder caps and check valve cases of triple valves. The nut used by the air brake manufacturing companies is not finished all over but is a cold-punched nut faced on the bottom and having dimensions across the flats 1/16 in. less than the U. S. Standard. The question was as to why it was necessary to go to the added expense of facing a nut that is only used to draw two castings together with a gasket between and why the U. S. Standard cold-punched nut would not do the job as well as a special nut furnished by the air brake companies. Chairman Wood replied that the committee considered the suggestion to see if there was enough saving in changing from one nut to the other. Its conclusion was that it did not seem to make any difference whether the common cold-punch nut or the finished nut or semi-finished nut was adopted, because any kind of a ½-in. nut will be found on triple valves that the repairman happens to get a hold of unless there is some one there to see that he can not get the wrong nut. If a railroad wants to put on the ordinary ½-in. nut, there is nothing to prevent it from doing so. Mr. Von Bergen said that he did not care so much what was made standard as to have a standard and avoid the waste involved in having so many kinds of nuts in use as there are at present.

The remainder of the discussion was devoted to the subject of the elimination of the angle cock on passenger cars. A number of the members reported the results of tests made on their roads with the object of eliminating the angle cock feature. Some members seemed to feel that trains could be operated quite efficiently without being equipped with angle cocks. On the other hand, some of the members reported that after a considerable number of tests, it was decided that they could not get along without angle cocks, as the delays were too great where trains are broken up and switched enroute. These members, however, expressed a willingness to give the matter further consideration, with the assistance of the committee.

The report was accepted.



Standard units of steel shelfing used in the tool room

Air Brake Association convention

Report on brake pipe leakage and paper on braking power of freight cars feature convention program — Total registration, 1,043

A TOTAL of 1,043 members and guests registered at the thirty-fourth annual convention of the Air Brake Association which was held at the Mayflower Hotel, Washington, D. C., May 24 to 26, inclusive. Of this number 549 were members of the association. The exhibit held by the Air Brake Appliance Association in connection with the convention, was also unusually large and complete, a total of 69 supply companies being represented in the exhibit.

The opening session of the convention was featured with addresses by Frank McManamy of the Interstate Commerce Commission and by R. H. Aishton, president, American Railway Association. These addresses were followed by the report of the president, M. S. Belk, general air brake instructor, Southern, Washington, D. C., who made a number of recommendations for the consideration of the executive committee among which were that the executive committee be increased from five to seven members, and that when it met to select a place for holding the annual convention representatives of the Air Brake Appliance Association be notified and invited to attend.

Following these addresses a tribute was paid to the late F. M. Nellis, who was secretary of the association from 1899 to 1926. The convention then proceeded to the presentation and discussion of the various reports and papers, abstrtcts of some of which are given herewith.

The program included a number of papers and reports on subjects that were practically new in the work of the association or had received comparatively little attention in past years. Two of the new subjects discussed were "Recommended practice on air brakes and foundation brake gear for gas rail cars," and "Air brakes for automotive vehicles." F. K. Vial, vice-president and chief engineer, Griffin Wheel Company, Chicago, presented a paper on "Standardization of braking power of freight cars," which will be published in a later issue of the *Railway Mechanical Engineer*.

Election of officers

The following officers were elected for the year 1927-28: President, H. A. Clark, Soo Lines; first vice-president, H. L. Sandhas, C. R. R. of N. J.; second vice-president, W. W. White, Michigan Central; third vice-president, W. H. Clegg, Canadian National; treasurer, Otto Best, Nathan Manufacturing Company; secretary, T. L. Burton. The executive committee, including the new members, stands: R. M. Long, P. & L. E.; W. F. Peck, B. & O.; C. H. Rawlings, D. & R. G. W.; E. Z. Mann, A. C. L., and E. VonBergen, Illinois Central. The association voted to hold its 1928 convention at Detroit, Mich.

Commissioner McManamy's address

The keynote of Commissioner McManamy's address, of which the following is a summary, was the common goal towards which the government, through the Interstate Commerce Commission and the railroads, through the various railway associations, are endeavoring to attain, namely, safe and efficient railroad transportation. The air brake is not only a safety device, but it is also a time saver and a dividend payer. It is just as important, he said, to make a smooth stop as it is to make a quick stop. The accomplishment of both of these requires men of trained skill and an idea of the problems that must be solved is perhaps best illustrated, he said, by the fact that the rate at which the air brake must do its work is about six times that of the work performed by the locomotive in starting the train.

Mr. McManamy expressed the belief that there is a real need for a more uniform standard of maintenance and mentioned the fact that the standards established by the Interstate Commerce Commission have been no more rigid than those recommended by the Air Brake Association. The Commission has practically followed the recommendation made by the Air Brake Association and according to the report of a recent investigation, he said, the present standards of maintenance are the high-

M. S. Belk (Southern) President — H. A. Clark (Soo Lines) First Vice-President — H. L. Sandhas (C. R. R. of N. J.) Second Vice-President — T. L. Burton (N. Y. C.) Acting Secretary

est they have ever been in the history of this country.

The railroads have not tried to evade the law relative to the application and utilization of new appliances and equipment, he said, but failures to comply have been due, almost entirely, to the lack of confidence in certain new features by the railway officers. As a result, the Commission has been required to do considerable educational work. As an instance, he said, compliance with the rule relative to the control of trains by the use of hand brakes required a lot of education.

The Mechanical Division, A. R. A., and the Bureau of Safety have been co-operating in the formulating of a standard maintenance code, and Mr. McManamy said that the Air Brake Association is having no small part in this work, as one of its past presidents, Geo. H. Wood (Atchison, Topeka & Santa Fe), is chairman of the Mechanical Division committee.

The number of defects and violations discovered are constantly decreasing. It is now generally appreciated by railway officers that the laws regulating the safety of railway transportation have many advantages, and they now insist on compliance, he said. This attitude he considers to be due to the work of the various railway associations and the increased activity on the part of the members in recent years. In the early years of railway association activities, Mr. McManamy said, the members attended the annual conventions on their own time and at their own expense, but that now they attend as authorized representatives of the railroad with which they are employed. The work of the associations is becoming of greater importance to the industry and he said that the Interstate Commerce Commission wants to co-operate in very way possible with any organization working along the same lines as the Air Brake Association.

Address by R. H. Aishton

R. H. Aishton in his address stressed the fact that there has been a most profound change in public opinion regarding the railroads during the past four years. Two of the most important factors in this change of attitude he considered to be the increased competition from other forms of transportation and the providing of better and more efficient service on the part of the railroads.

"One of the things that has made this speeding up of service possible on the part of the railroads," he said, "has been the development of the air brake which has now reached the highest point in satisfactory service ever attained so far as train operation is concerned. Not only is the air brake a material factor in safety, but due to having a dependable braking system, the railroads are able to obtain more nearly maximum efficiency out of their locomotives because trains can be operated with less wastage of time in stopping and starting. Delays along the line, which in the past have been at times responsible for serious accidents, are also now being reduced owing to fewer air brake troubles.

"The fullest co-operation exists between the Bureau of Safety of the Interstate Commerce Commission and the railroads in respect to the adoption, promulgation and enforcement of regulations relating to the use of air brakes. These rules and regulations represent a practical minimum requirement. They are not 100 per cent perfect, but the problem is not so much to make the rules better, but to see that they are observed. As a result, according to the last annual report of the Bureau of Safety, 'It is now universally conceded that air brake conditions throughout the country are the most satisfactory ever known, both with respect to law compliance and satisfactory train operation.' In behalf of the railroads of this country, I can assure the Commission of their appreciation of this spirit of co-operation and of their desire to take advantage of every method leading to safety, economy or efficiency."

Main reservoirs

The purpose of main reservoirs on a locomotive is to provide for the storage of an ample supply of cool, dry, clean air so that the brake system may be charged and recharged promptly and the auxiliary air operated devices properly controlled. When functioning as intended in conjunction with suitable air compressor capacity and piping, moisture, oil and other foreign matter will be trapped in the main reservoirs. Unless this is done, these substances would greatly interfere with the operation of feed valves, brake valves, etc.

In the early days of the compressed air brake, corrosion of main reservoirs played little part. Reservoirs have been removed from locomotives after many years of service, and found in first-class condition. What caused these old reservoirs to outlive the locomotive, when reservoirs are now sometimes so short-lived in certain localities? Any one of four factors, or a combination of them, is undoubtedly responsible:

First—The absence of cooling pipes caused little moisture to be trapped in the main reservoirs.

Second—The amount of air compressed in a given time was much less than at present.

Third—It was common practice to use reservoirs of a length about equal to the diameter.

Fourth—It is possible that the material then used had different characteristics with respect to corrosion than the material generally employed at present.

In explanation of the above, it might be said that it was common practice to pipe direct from the air compressor to the main reservoir, without regard to radiation. The compressed air passed through the main reservoir while hot, and into the brake system. Little moisture collected in the reservoir to induce corrosion. The reservoir being of about equal diameter and length, the area covered by any water that collected was small and could be well drained, even if it or the locomotive was not level.

While the main reservoirs did not suffer from corrosion, much trouble was experienced with erratic action of the valves, and with the moisture freezing back in the train, and the uncooled air affected the filler in the leather gaskets. Unfortunately the more efficient the design of the air cooling and storage system, the greater is the concentration of corrosive elements in the main reservoirs.

Briefly, corrosion is caused by the presence, mainly, of moisture and oxygen. Other factors, of course, contribute to the activity of corrosion, such as salts of various kinds and acids. In the functioning of the air brake system on a locomotive, the various factors noted above are found in abundance. Thus, there is moisture precipitated due to the cooling of the compressed air; oxygen, which forms one-fifth of the air, and corrosive salts and acids, mainly sulphates and sulphuric acids.

(The report contained here a number of tables showing an analysis of drainage water taken from the main reservoirs of locomotives operating in various sections of the country.—Editor.)

It is evident that any effort made to arrest or retard corrosion is a step in the right direction; thus, main reservoirs should not only be drained before each trip, as required by the federal law, but at intervals during the trip, if convenient, to reduce the concentration of corrosive elements that build up. This is especially im-

portant on long engine runs. This is also to guard against moisture being carried over into the brake system.

Reservoirs should not be placed so that they will be subject to extremes of temperature from the fire-box or boiler. In recent years, various materials have been developed which are intended to effect a reduction in the rate of corrosion, by forming protective coatings and retarding the chemical activity of the corroding mediums. The use of such compounds suggests itself as a possibility.

Hand-holes should be considered to facilitate cleaning out main reservoirs, because there is no doubt that accumulations of various salts and acids are not without effect in accelerating corrosion.

On cutting failed reservoirs open, large quantities of rust, oil and foreign matter have been found. This is particularly true of the reservoir which is connected directly to the compressor discharge. One reservoir was found to contain 120 lb. of foreign matter. It is evident from this that foreign substances cannot be entirely expelled through the ordinary ½-in drain cock.

An investigation should be made to ascertain what metals are available which are less susceptible to corrosion.

The experience of the members of the Pittsburgh Air Brake Club has covered plain steel, enameled steel, copper-bearing steel, and wrought iron, as materials for main reservoirs. There appears to be little data available as to the average length of life of main reservoirs. Some manufactured of enameled steel and copper-bearing steel have been known to fail in about six months, while others of the same materials have given service for many years.

On a tunnel division of one railroad, much trouble was experienced with enameled steel and copper-bearing steel reservoirs failing the hammer test at the first general shopping of the engine. Ordinarily, reservoirs fail on the bottom where the condensation lies. If they are too close to the boiler, frequently they fail at the point subject to the greatest heat.

The pits resulting from corrosion are generally small, which makes it advisable to use a pein of about 3/16 inch radius when hammer testing. A two-pound ball pein hammer is much too large for this work. When hammering on the bottom, each square inch should be struck.

Three hand-puddled wrought iron reservoirs were applied for test early in 1924. Twenty-five months later one of these reservoirs was removed and cut open. It was found that the corrosion was general and not pitted, and the metal at the thinnest point had lost by corrosion only .006 inch. The other two test reservoirs are still in service, after a period of over three years.

When reservoirs receive hydrostatic test while in place on the engine, some method should be used to expel the air. One road taps all reservoirs ¼ inch diametrically opposite the drain hole. A ¼-in. drain cock is applied and opened. When the water appears at this cock, it is closed.

It is the recommendation of this club that the Air Brake Association appoint a committee to investigate and advise in regard to the following:

First—Whether facilities should be provided for interior inspection and cleaning.

Second—Whether a larger drain cock should be used.

Third—Whether additional bosses for drain cocks should be provided, so that reservoirs can be turned at each shopping or test period.

Fourth—If reservoirs should be tilted and the drain cock placed near the head so that more perfect drainage can be obtained.

Fifth—What material possesses characteristics most suitable for main reservoirs.

Sixth—What rust preventive coatings are available which will materially increase the life of reservoirs.

(This paper was contributed by the Pittsburgh Air Brake Club.)

Discussion

The discussion on this report was opened by W. F. Peck, Baltimore & Ohio, who said that the railroads should be more particular as to the location of the main reservoir on the locomotive and that some provision should be made for periodic washing out. It was also brought out in the discussion that sulphuric acid will not corrode metal if moisture is not present. Several of the speakers recommended that reservoirs should be stenciled with the date of building and application to the locomotive and practically all the speakers agreed that there was need for some provision for better draining and cleaning. W. H. Clegg, Canadian National, reported that his road was considering main reservoirs with detachable heads. Some objections, however, were raised to this type of construction on account of the extra cost. One of the members reported that his road cleaned main reservoirs periodically with Oakite solution, rinsed them and then sprayed the interiors with a metal preservative solution. The Missouri-Kansas-Texas, one member reported, has adopted the practice of painting the inside of main reservoirs used on its locomotives.

Recommended practice on air brakes for gas rail cars

Motor cars in service and building, which are designed to handle a standard passenger coach as a trailer, require a combined automatic and straight air brake equipment. Some motor cars have sufficient power to handle a number of standard passenger or freight cars on low speed schedule, or in switching service and, therefore, should be equipped with an equalizing piston type of brake valve.

Inasmuch as the straight air system will apply the brakes on the motor car only, it should be used only when the vehicle is in single car service. A cut-out cock is provided in the straight air pipe under the brake valve, so that the straight air system may be cut out when operating a train of two or more cars. During single car operation, air is admitted at feed valve pressure through the straight air application and release pipe to the double check valve and from there to the brake cylinder to apply the brakes, which may be graduated on or off in any number of stages, under the direct control of the engineman. This is the most reliable flexible brake control, and for that reason is supplied for single car operation.

When operating a train, the straight air feature should be cut out and brake pipe reductions and recharges made in the usual manner. It should be noted, however, that it is impossible to overcharge during normal operation, for the feed valve supplies all air to the brake valve, and there is, therefore, no position where main reservoir pressure can be introduced into the brake pipe. The handle "off" position is required on double end equipments to prevent manipulation of the non-operative brake valve by unauthorized persons, for it may be located in a position partially exposed to passengers. The emergency position of the brake valve performs the usual functions, namely, to create a rapid reduction in brake pipe pressure, and in addition also to charge the

straight air by-pass pipe. If for any reason the triple valve or valves fail to apply, a straight air application will be secured on the motor car, for the by-pass pipe is connected to the straight air pipe at a point below the straight air cut-out cock. This is also a non-return check valve with an orifice, through the valve itself in the straight air by-pass pipe, which reduces the rate of straight air application in emergency, so that the triple valve can still vent brake pipe air to the brake cylinder, and also freely permits straight air release.

Where trailer cars are supplied with these motor cars they should be equipped with a standard passenger car brake arrangement and include a triple valve having functions identical with that on a motor car. Hose connections, couplings and angle cocks should be supplied with these units in accordance with steam road standards.

There are about four different types of compressors and compressor control units which have proved fairly satisfactory in service and which are being installed on the majority of all cars under construction at the present time.

With the gas electric vehicles it is, of course, apparent that a motor driven compressor with a pneumatically operated switch, which will cut the pump in and out between definite specified pressures, is ideal.

With the gas rail cars, where there is no major source of electric power supplied, the compressor must be mechanically driven. These mechanically driven compressors may be controlled in either one of two ways: Either by de-clutching the compressor when the maximum pressure has been attained and then resuming operation when the minimum pressure is reached through the medium of a pneumatic governor, or by unseating the suction valves with a similar control device working on a definite range. While these two systems of compressor control have their advantages as well as disadvantages, it is hardly the purpose of this paper to discuss this in detail, for they have both proved quite satisfactory in service.

The fourth method of compressor arrangement will be found on recently constructed cars where it was desirable to use a high speed, air cooled, two cylinder compressor with mechanically controlled suction valves. This suction valve arrangement is fundamental to a successful high speed compressor, for the limit of speed of compressor operation with automatic suction valves is dependent upon the effective speed of the valve opening and seating. With this type of compressor an arrangement has been developed so that the governor instead of supplying air to unseat the suction valve, in effect unseats auxiliary valves in the compressor head, which when opened connect the cylinders together with the result that there is no net piston displacement for the combined unit. No air is, therefore, supplied by the compressor when the governor cuts out.

Recommended practice for foundation brake gear

The present gas-rail and gas-electric motor cars are closely similar in their details of construction and operation to standard traction or electric railway units in service today. The gas electric truck is a traction truck, and although in the gas rail truck the motors are replaced by the differential and drive shaft, the fundamental controlling factors actually put this truck in the traction class, especially the power truck. For these reasons, these cars have been braked in accordance with traction standards; that is, 100 per cent brake ratio based on 50 lb. cylinder pressure.

Motor car trains with a standard passenger coach as a trailer will, therefore, have a more effective brake on the motor car than on the trailer, in the ratio of 100 to 75 for a full service application. The slack action in a two-car train under these conditions it was thought would not be noticeable, and the tendency would be to keep the slack in during a brake operation. One reason for using a higher ratio for these units than the steam road passenger ratio of 90 per cent on 60 lb, is that considerably shorter stops could be secured with a higher ratio, with which there is greater protection against wheel sliding than on standard passenger cars, for the brake control is much more flexible. Because feed valve pressure is available with a straight air application, restricted slightly, however, by the spring in the double check valve, the full straight air service brake ratio is 135 per cent approximately. The high emergency feature of the triple valve also provides for 135 per cent approximate brake ratio in emergency.

The short wheel base of these trucks requires the use of the single shoe type of brake rigging, and on account of the installation of a drive shaft and differential on the gas rail trucks, and the motor on the gas-electric trucks, the truck levers should be located between the wheel treads and connected to the pull rod through the medium of an equalizer bar. Because the shoes must be considerably below the wheel centers to prevent journal displacement and tilting, and to allow for rail clearance of the bottom rod, truck ratios should be comparatively high, and the total possible travel of the live truck lever is limited so that on most trucks that is the primary point of brake rigging fouling with excessive shoe wear. With these limitations, therefore, it is obvious that a brake rigging with a nominal initial brake cylinder piston travel of approximately 5 inches will permit of a greater linear shoe wear than a similar rigging with 8 inches initial travel; i. e., with 5 inches initial piston travel the car can make greater mileage between bottom road slack adjustment take-up periods than with 8 inches initial piston travel.

For these reasons the traction standard of 5 inches nominal piston travel should be adopted for these equipments and auxiliary and supplementary reservoirs should be accordingly reduced in size so that full equalization only will be obtained with a 20-lb. reduction off of 70-lb. brake pipe with the brake cylinder travel at 5 inches. Gas-rail and gas-electric brake equipments should, therefore, have auxiliary and supplementary reservoirs of smaller size than has previously been standard for steam road service where the piston travel has been based on 8 inches.

Recommended practice for the total maximum leverage ratio on steam road passenger cars varies from 9 to 1 with 8 inch and 10 inch equipment to 5½ to 1 with the double 18 inch. Traction car recommendations, however, permit the use of a 12 to 1 total leverage ratio, though 10 to 1 is acceptable as a maximum where it is feasible for the particular car design under consideration. Account of the traction characteristics of these trucks, the recommendations are for the traction standards, i. e., with a maximum total leverage ratio of 12 to 1. This recommendation is logical and based on engineering requirements.

With any car having this type truck, with a fixed truck ratio, where the travel of the top of the live lever is the limit of the brake effectiveness, it is obvious that the total leverage ratio of 12 to 1 will not permit as great a car mileage between bottom rod slack adjustment periods as would a lower total leverage ratio. In explanation we might add that with a fixed truck ratio, the higher the total leverage ratio, the higher will be the cylinder leverage ratio, therefore, with 5-inch initial piston travel the high cylinder leverage ratio will pro-

vide greater remaining live lever travel available for shoe wear.

The brake rigging for these gas rail and gas electric cars should be designed in accordance with A.R.A. stress limitations. When it is found desirable to use high carbon or alloy steel for the foundation brake details, higher maximum stresses are, of course, permissible.

It is recommended that brake shoes be adjusted with 1/8-inch clearance. Brakes will be set with a movement of from 2 in. to 2½ in. at the top of the live lever, giving a 4-in. to 5-in piston travel. Total travel of the live lever is ordinarily limited to 5 inches, which gives from ½-in. to ¾-in. shoe wear. The live levers should be connected at the upper end with an equalizing bar, which insures even pressure being applied to each side of the truck.

Probably one of the first things that will attract the steam road brake expert's attention will be the slender construction of the brake parts. This is largely due to the use of special materials. It should be the practice to use the S. A. E. No. 1035 specification steel for levers and equalizers. After these parts are forged they should be annealed. This steel has a tensile strength of from 75,000 to 80,000 lb. with an elastic limit of from 40,000 to 45,000 lb.

In order to reduce weight, advantage should be taken of the increased strength and stiffness of this steel, so that brake beams, equalizers and levers can be figured with a 23,000 lb. fibre stress with service application of brakes. With emergency application the fibre stress will, of course, be increased. In comparing this practice with standard A. R. A. practice, using ordinary steels of from 55,000 to 60,000 lb., tensile and elastic limits from 27,000 to 30,000 lb. per square inch, being worked at a fibre stress of 23,000 lb., as compared with a steel having an elastic limit of 40,000 lb., with ordinary working load of 23,000 lb. fibre stress, and in an emergency application of 135 per cent of the normal, the fibre stress would be 31,000 lb.

It is readily seen by comparison that the maximum fibre stress is proportionately the same in these standard materials: 23,000 to 30,000, and 31,000 to 40,000.

In case of accident, it will hardly be necessary to replace the brake parts from standard stock, as their position in the truck almost precludes their being damaged. If they should become distorted, it will only be necessary to reshape them and after the forging operation is completed bring them to a dull cherry heat and allow them to cool slowly in a furnace.

As to the necessity of replacing them on account of wear, all the holes should be fitted with case hardened bushings and the pins should be case hardened. It would, therefore, only be necessary to replace worn bushings, as the life of the parts would be indefinite.

The entire equipment, body, trucks, brakes, etc., should be laid out to give the maximum strength for the weights allowed for this class of car.

Recommendations

The above represents the conditions under which gas-rail cars have previously been constructed, but as some of these conditions are not in accord with the standard steam road recommendations your committee submits the following for your approval:

Trucks and car bodies should be so designed as to permit full piston travel without interference of any of the parts and permit the use of the total lever ratio as recommended for standard steam road passenger cars.

Where compressors of the electric-drive type are used they should be controlled by a pneumatic device that will control them within a definite range of not to exceed 10 lb. variation.

Mechanical driven compressors should be equipped with a pneumatically-operated device restricting further compression when the maximum pressure is obtained.

Compressors of the following capacity are recommended: For the motor unit not less than 16 cu. ft. per minute and an additional 10 cu. ft. for each trailer anticipated.

All compressors should be equipped with a device between the strainer and compressor to prevent freezing.

Main reservoir capacity to be not less than 10,800 cu. in. for a 10 in. cylinder, and when additional reservoir capacity is desirable, two or more reservoirs should be used, and the additional reservoirs should be separated from the first by a "parasite" governor.

Main reservoirs must be equipped with a safety valve that will open at not to exceed 10 lb. above working pressure.

All piping of motor cars to be of wrought iron or copper.

All brake valves to be of the rotary type with an equalizing piston. Straight air and automatic features integral.

A feed valve should be located in the main reservoir supply pipe between the main reservoir and brake valve at a point convenient to the engineman. This is to reduce main reservoir pressure to that of the brake pipe.

Gages should be located at a point convenient to the engineman from his usual position in the cab, indicating main reservoir, equalizing reservoir, brake pipe and brake cylinder pressures. A feed valve and non-return check should be located in the straight-air pipe below the brake valve and above the straight air cut-out cock, so that the straight air pressure may be reduced to a nominal force when used.

A cut-out cock should be located in the brake pipe below the brake valve at a point convenient to the engineman. This to be closed when the car is being handled dead in a train.

A double check valve known as the No. 14 double check, should be located at a point convenient for inspection and repairs, between the brake valve, triple valve, auxiliary reservoir and the brake cylinder.

Where double-end control is desired, duplicate equipment should be supplied for each end of the car and the straight air pipes should be equipped with a double throw check valve at their junction with the pipe leading to the No. 14 double check valve.

The triple valve should be of the quick service, quick recharge high emergency cylinder pressure and graduated release type, with a supplementary and auxiliary reservoir of proper size to produce a braking ratio of 80 per cent on 50 lb. cylinder pressure.

To safeguard against total loss of brakes in case of top or truck rod failure on either end of the car, it would be our recommendation that cars of this type be fitted with two brake cylinders braking each truck independently. The hand brake to work on both trucks and in harmony with the power brakes.

(This paper was contributed by the Central Air Brake Club.)

Brake pipe leakage

The meaning of the term "Brake pipe leakage" as used in this report can be defined as leakage from the brake pipe volume only. This leakage is measured by observing the rate of drop in brake pipe pressure during the standard A. R. A. brake pipe leakage test.

The meaning of the term "Brake system leakage" as used in this report can be defined as the leakage from the brake pipe volume plus leakage from the auxiliary reservoir volumes which are connected to the brake pipe through the feed grooves when the triple valves are in release position. This leakage is measured by observing the rate at which compressed air must be supplied to the train in order to keep the brakes released and fully charged.

Since the last meeting of the Association, your committee has confined its activities largely to the investigation of brake installation on freight cars in service. The two previous reports covered a large number of brake pipe leakage tests made with measuring instruments and soap suds. The data of those tests were tabulated, averaged and analyzed so that they gave a fair presentation of the leakage conditions as they existed during the years of 1924 and 1925. Some leakage tests were made

during this year, but the data have been omitted from this report because they had no special significance other than what had been demonstrated in the previous reports, unless it was to show that brake pipe system leakage conditions are improving at a rapid rate. In all of the committee's endeavors the improvement of the average condition of train leakage has been very noticeable so that we feel that the work of this committee and all those who are interested in this subject, is beginning to pay dividends. The value of those dividends is probably greater than is generally realized.

In this report we have planned to present the results of an investigation which deals with ways and means for improved brake equipment maintenance. This is a large field which could only be investigated in part, but we are confident that the recommendations of this report cover some of the most important aspects of the maintenance problem.

Train tests

The brake system leakage testing device, which has been fully described in the previous reports, has been placed in continuous operation at several localities under the observation of members of this committee. This testing device was primarily designed to measure the total leakage of air from the train brake system and it accomplished this purpose by measuring the amount of air required to keep the front end of the train properly charged. Two methods of manipulating the testing device when making this measurement have been proposed, but the method covered in the last report has demonstrated some distinct advantages.

The brake system leakage testing device roughly described, is a ¼-in. diameter orifice which will measure the amount of air used to charge a train by observing the differential of pressure on its two sides when the front end of the train is held charged.

The new method requires that the supply pressure, which may come from a yard plant or locomotive, will be maintained at 70 lb. pressure and the charging differential determined by noting how near the head end of the train under test can be charged to 70 lb. pressure when supplied through the ¼-in. orifice. The limiting of the supply pressure to 70 lb. is a distinct advantage because it eliminates danger of overcharging and makes the handling of the testing device much more convenient for quick and accurate determination of the train leakage.

In addition to the advantage named, the limiting of the supply pressures to 70 lb. has made it possible to increase the usefulness of this testing device by permitting it to be used for making a release test on the train.

The most serious defect encountered in the operation of long trains is the difficulty of releasing brakes near the rear end. Triple valves are in the habit of wearing out and as they wear, the piston ring leakage increases, which in turn increases proportionately the difficulty of releasing such triple valves near the rear end of the train. Such triple valves are not numerous, but when they do happen to get located as described, burned brake shoes, slid flat wheels and other serious troubles result.

It so happens that the ¼-in orifice when supplied with 70 lb. pressure will build up a volume from 50 lb. to 70 lb. at nearly the same rate as will a standard C-6 feed valve in average condition set to close at 70 lb. and supplied with a main reservoir pressure of 90 to 100 lb. It is evident, therefore, that when a train is charged to 70 lb. and a 20-lb. reduction is made, if the train is released by building the brake pipe from 50 lb. to 70 lb. through a ¼-in. orifice, the build up rate will be about the same as could be expected if the train was released with an engine having standard equipment.

Any brakes in a train which do not release with the brake system leakage testing device used as described, can be assumed to be brakes which might not be released by the locomotive itself and, consequently, a train should not be permitted to leave the terminal until such cars have been switched out for further examination and tests designed to locate the defect.

The brake system leakage testing device was changed to provide facilities for making a brake pipe reduction so that the release test could be made and the train inspected for brakes failing to release. The testing device will serve not only to indicate bad leakage conditions but it will assist in locating other defects which may interfere with the brake operation. Consequently, the value of the device is considerably extended.

It should be borne in mind, however, that this testing device is intended for use only to test trains just previous to the time of their departure from the terminal. The release test described is distinctly an operation test which in long trains will only pick out cars that are defective much beyond the degree determined by the limits of the various individual testing devices provided for the accurate testing of each part.

The brake system leakage testing device was placed in regular service at an important terminal of a large railroad system beginning on May 1 of last year. The traffic at this point is mostly through-bound. The trains are stopped only to change the power and in a few cases trains are switched.

Since May 1, 1926, an accurate record has been kept of all cars found in trains with defects, determined either by the leakage test or the release test. In every case such cars were removed from the train to the rip track, where, with the use of the single car testing device supplemented by the 3-T triple valve test rack, all defects were located and recorded before repairs were made. In no case was a car removed from the trains which did not show up a serious defect when given detailed investigation at the rip track. The inspector in charge of this work kept a complete record of each car removed and of each defect found. The most important facts determined from an analysis of this data are as follows:

1—A total of 1,060,752 cars were dispatched in the trains tested during eight months and 1,231 cars were removed as unfit for service. This is about one car in 861 or one car in ten 86-car trains.

2—The 1,231 defective cars removed in eight months represents about five defective cars per day.

3—Nearly one-third, or 30.8 per cent of the car defects were caused by leaky packing rings.

4—Nearly one-fifth, or 19.6 per cent of the car defects were caused by leaky brake cylinder packings.

5—Nearly one-eighth, or 12.1 per cent of the car defects were caused by leaky brake cylinder gaskets.

6—Cars defective within 30 days, 8.8 per cent; cars defective within 60 days, 17.1 per cent; cars defective within 90 days, 27.1 per cent.

Brake equipment installation

Your committee made an investigation of freight car brake installations with the object of determining what brake installations methods or change in methods could be recommended as a means toward reducing brake system leakage and maintenance expense.

Throughout the work of this investigation we have endeavored to judge merit on the basis of performance proved in service. Many of the problems met with have been before the members of this association as well as the car builders for many years. Only the best

possible solution of each installation problem will make the equipment installation as a whole what it must be if we are to attain satisfactory operation at the lowest cost.

Pipe clamping

A very common defect is loose or broken pipe clamps. More than one-third of the cars examined by and for the committee had missing or defective pipe clamps. The proper solution of this problem is extremely difficult because the rigidity of the car has a direct bearing on it. It is obvious that if a car is poorly designed and used in heavy load service where long trains are handled, the deflection of the car members may be such that almost any form of clamping will be futile unless the pipe is provided with expansion sections suitable to take care of the body deflection.

Frequently a car is designed to have the brake equipment securely clamped at every convenient point, but the clamps cannot be maintained. In some of these cases the installations can be improved by omitting certain clamps because of deflection conditions in the car frame. The proper clamping of the brake system piping is a problem which can only be settled by a study of each individual car design and where deflection of the car members or equipment mounting brackets is unavoidable, the car piping should be installed so that the necessary flexibility will be provided.

Pipe threads and tapered fittings

During the study made of brake installation conditions as related to brake system leakage, there was one factor which frequently played an important part in pipe failures. That factor is the sharp bottom thread which is a part of the Briggs pipe thread standard. Many brake equipments are arranged so that maximum bending strain comes on the pipe at the thread where the pipe enters the fitting. The thread, of course, cuts away a portion of the pipe section which makes this a weak point, but this weakness is further increased because the thread groove is sharp at the bottom and is very favorable to the progressive fracture of the metal. If the bottom of the pipe thread was flattened off or rounded, the strength of the threaded pipe would be greatly increased.

This is a matter which will be very difficult to correct because it involves a change in a universally used standard, but we believe it is worth while to call attention to it at this time because the point should be kept in mind when future revisions of the pipe thread standard are under consideration. The Whitworth thread standard is undoubtedly better than the Briggs standard because of the liberal radius or fillet in the bottom of the threads which adds greatly to the strength of the pipe or the fitting at its weakest point.

There are, at the present time, a great many pipe fittings in the range of sizes used in brake installations which are made with straight threads. The straight tapping of such fittings cheapens their production and all dependence for a good pipe connection is placed on having a tapered thread on the pipe. When a tapered pipe thread is screwed into a straight tapped fitting all the tightening of the joint takes place on the first or second thread of the fitting unless the pipe is screwed in sufficiently tight to deform the fitting. This is not good mechanical construction and the use of such fittings for air brake work should be discouraged.

There are some lines of fittings now on the market made up especially for railroad use, which are properly tapped and if the use of straight tapped fittings is to be avoided, brake installation specifications should be written accordingly and straight tapped fittings should be eliminated from railroad storerooms. The natural difficulty of making up a tight pipe joint in car piping and maintaining that joint tight is so great that the handicap imposed by the use of straight tapped fittings cannot be justified.

Angle cocks

A 30-day check was made on the number of angle cocks and pipe nipples, broken off at a certain terminal where a total of 55,703 cars were dispatched in that time. The result of this investigation was as follows: 65 angle cocks broken off with the threads in the cock body destroyed, 187 angle cocks broken off at the nipple, 137 angle cocks broken off at the nipple ahead of the coupling, and 95 angle cocks broken off back of the coupling.

Your committee realized that these results are partly chargeable to the poor installations of the angle cocks on the end of the cars because if the angle cock is not properly located it may be difficult to keep the hose gaskets tight and if it is not properly fastened, the stress which the cock body must resist when cars are pulled apart without uncoupling the hose may be such that the pipe threads may be damaged or the cock body distorted.

In investigating the very prevalent defect of leaky angle cock keys, it was determined that many of these could be repaired by relubricating the cock, but in some instances this was not a remedy because the distortion of the cock body had spoiled the fit of the key and proper repairs required that the cock should be removed and refitted. The mounting and locating of the angle cock on the end of freight cars is a problem which has been dealt with in many ways and but few of the solutions can be considered good enough if the hose gasket, cock key and thread leakage is to be held to a minimum.

During one investigation 40 box cars were examined just as they came from the shipping track of an industrial plant, and of these forty cars there were 19 different ways of mounting angle cocks.

The fundamental requirements for the proper mounting of an angle cock at the correct location on the car are as follows:

1—The cock should be held securely by clamping the body of the cock.

2—The cock should be securely held at the proper angle and should be prevented from turning.

3—The cock support should be such that any strain on the cock from clamping, pulling of the hose, or otherwise should not be transmitted to the pipe threads.

The correct method of installing angle cocks is shown in the sketches of Fig. 1. One objectionable feature of this arrangement is that in order to install the clamp and insure that there will be no strain on the pipe threads, it is necessary to make the length of the angle cock nipple very accurate. If this nipple is too long it will not be possible to fasten the clamp because the U bolt will not align with the holes in the bracket, and if the nipple is too short, the endwise clearance in the hexagon portion of the clamp will be taken up in the direction towards the car so that all pulling strains will be transmitted to the pipe threads. This difficulty could be overcome to a considerable extent if the U-bolt holes in the supporting bracket were elongated so as to provide for some variation in the length of the standard nipple. A better angle cock installation could be made with this clamp if it was arranged to clamp on the angle cock body instead of on the pipe.

Among the most common defects which require cars

to be set out of trains for repairs are broken pipes. At one terminal from which 114,070 cars were dispatched in 60 days the records show that among these cars there was found a total of 59 cars with broken brake pipes and 105 cars with broken cross over pipes. The cost of these defects aside from the cost of the repairs is not always appreciated because switching cars out of and into live trains, and delays to shipments, are factors which vary and are difficult to evaluate in terms of actual cost. At this particular terminal it is estimated that the expense for removing cars from a train to the rip track and replacing them in a train is not

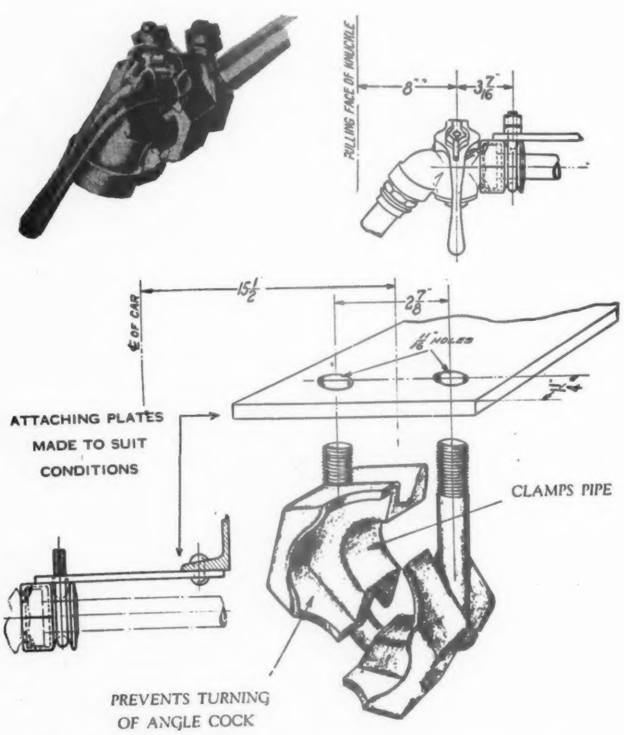


Fig. 1—Correct method of installing angle cocks

less than $10 per car. When this cost is added to the cost of the repair and the delay to shipments it is obvious that it will pay well to have a freight car and its equipment designed so that it will stay in continuous service between the regular inspection and cleaning periods.

Mounting brake cylinders and reservoirs

Investigations of brake failures due to leakage revealed that in many instances the cause of a defect could be traced to the improper mounting of the brake equipment device such as the brake cylinder and auxiliary reservoir. When these parts are not firmly attached to the car frame the effect of the brake cylinder reaction and moments of inertia of parts, due to train shocks, is such that they can move relative to the piping and each other. If the main brake pipe is properly clamped these movements cause strains in the branch pipe and the connecting pipe between the brake cylinder and auxiliary reservoir, which not only frequently causes a failure of these pipes, but in the case of the branch pipe it is frequently responsible for serious leakage defects which develop at the triple valve union, the dirt collector, cut-out cock, fittings and branch pipe tee.

The special branch pipe and cylinder pipe arrangements are, of course, designed to avoid these strains, but your committee believes that the proper mounting of the equipment parts should receive attention because we all know that it is much better to cure an evil by removing the cause than by making a change which will only modify the effect.

At the present time brake cylinders and reservoirs are mounted by bolting to the car frame or brackets through flanges which have cored holes. These cored holes have considerable clearance for the bolts used, and no matter how tightly the bolts are drawn up the mounting eventually becomes loose, due to the constant play of forces.

It is obvious that a considerable increase in cost would be warranted if the mountings could be constructed so that a brake cylinder or reservoir would remain firmly fixed in its location for a much longer period than is now common. A great improvement would be accomplished if the holes in the car frame or brackets could be drilled to fit the holes in the feet of the brake cylinder and reservoir using accurate drill jigs so that these parts could be firmly bolted to the car with bolts that fit closely in the holes. There was some justification under those circumstances in the use of cored holes having large bolt clearance. With the present modern steel construction employed on all freight cars there is no longer any excuse for not making a more mechanical job of this important feature of installation.

Brake system leakage testing device

The two tests accomplished by the brake system leakage testing device, namely, the leakage test and the release test, have condemning limits which are not in any way related to the length of train which happens to be under tests. The plan of using the brake system leakage testing device and the limits above described has worked out very well for the purpose intended but there are some conditions in classification yards which it is difficult for the device to meet. One of these conditions is where trains are made up in short sections which are distributed on various tracks, so that when the train is ready to go, the road locomotive is used to switch the train together.

Usually when such a train has been made up it is in a position which either blocks the yard tracks or the main line, so that it must depart immediately. Any testing or switching required at this time would cause an intolerable delay; consequently, it is desirable that the train be tested in short sections and known to be in good order with respect to the leakage and release test before the road locomotive is called to switch it together and depart.

To accomplish this purpose it will be necessary to modify the testing device so that its test limits will be based on train lengths, assuming the present limits to correspond to a train length of 100 cars. On this basis the orifice used in the device can be changed in steps for each difference of 10 cars in train length so that both the leakage and release test will have equal severity at all train lengths to that which the present limits provide for 100 car trains.

In order to do this with the test device in its present form, it would be necessary to change the orifice size each time that a different length of train is tested and the tester would be required to carry properly calibrated orifices for that purpose. This would not be a very convenient arangement and for that reason a new form of the testing device is being developed which will be designed so that the size of the testing orifice can be conveniently changed without requiring the operator to do more than what would be the equivalent of moving a brake valve handle.

This form of the device will be made up similar to

the single car testing device having a handle operated rotary valve for controlling the main connections and the orifice portion will be similar to a device used on the 2-T test rack which was arranged to change the orifice size by turning a notched wheel. This device will permit making the tests just as specified at present if the ¼-in. orifice is used and if it is desired to test different lengths of train with the same severity as the present limits would provide for 100-car trains, the smaller size orifices chosen in accordance with train length can be used. A diagrammatic assembly of the new form of brake system leakage testing device is shown in Fig. 2. When the device has been developed

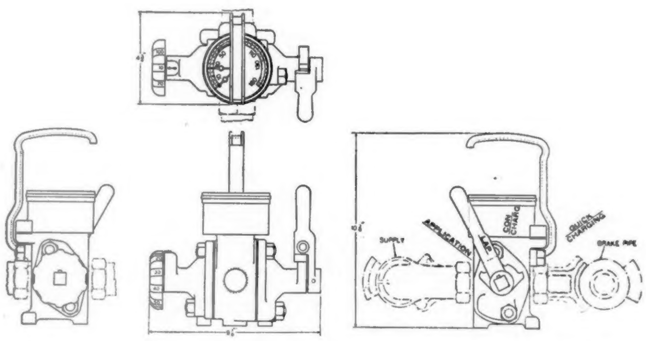


Fig. 2—Proposed brake system leakage testing device

to a point where its suitability for the purpose is properly demonstrated, it will be announced as available.

It is the judgment of your committee that an analysis of the data of this report will warrant the following conclusions and recommendations.

Conclusions

1—That adequate leakage and operation tests of freight trains before departure from terminals will serve to detect brake equipment defects which materially decrease the efficiency of brake operation.

2—That the proper repairs of defects as such tests will detect will serve to reduce delay caused by stuck brakes, slid flat wheels, etc., and the tests provide a check on poor quality repair work.

3—That many conditions which contribute to brake system leakage are unnecessary and can be eliminated by proper provision in the brake equipment installation design.

4—That the angle cock with supporting flange will provide a good mechanical construction basis for fixing and maintaining the angle cock in its proper location, thereby avoiding unnecessary strains in the piping and avoiding leaks due to improper position of the hose.

5—That metal joint unions are preferable to ordinary unions for use in brake equipment piping.

6—That the use of straight tapped pipe fittings in brake equipment piping is undesirable.

7—That better mounting of brake cylinders and reservoirs is desirable because if these parts can be permanently held in a fixed position, damaging strains on the piping and fitting will be avoided and maintenance cost will be correspondingly reduced.

8—That maintenance cost can likewise be reduced on old cars if branch pipes and crossover pipes are installed to have flexibility and thereby avoid strains at the devices and the threaded joints.

9—That the use of reinforced pipe fittings is warranted by the severe conditions which surround piping in freight car service because those fittings will make the equipment more nearly leak proof and thereby avoid a maintenance expense which goes on continuously.

10—That the standard A. R. A. brake pipe leakage test is inadequate because it is not dependably accurate at leakage rates greater than 5 lb. per minute.

11—That the limit rate of brake system leakage suggested in the last committee report is not too low. (The limit suggested was fixed at 36 cubic feet of free air per minute for a train of 100 cars or less.)

12—That the proposed form of the brake system leakage testing device will provide means for testing trains of any length up to 100 cars with uniform severity.

Recommendations

1—That this association refer the question of making leakage and release tests on freight trains in terminals to the American Railway Association with a view to making such tests together with proper repairs standard A. R. A. practice.

2—That the suggested modification of the present standard and brake pipe leakage test described in this report be submitted to the American Railway Association for consideration.

3—That the suggested leakage limit for brake system leakage be studied with a view to reducing it from 36 to 25 cubic feet of free air per minute.

4—That brake installation design be made a regular division of study in the recommended practice of this association.

5—That the angle cock with supporting flange be made standard on all new cars and methods devised for using it on all cars when old style cocks must be replaced.

6—That reinforced pipe fittings be given a more extensive trial by specifying them for cars in heavy load service.

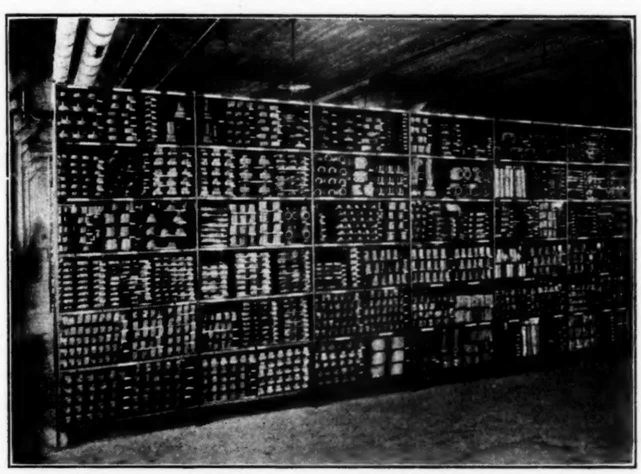
7—That brake cylinders and reservoirs together with their mounting brackets be drilled with accurate jigs to insure a more permanent and rigid mounting.

8—That when necessary to repair broken branch and brake cylinder pipes, such pipes be replaced by a flexible combination which will present the transmission of strains to the pipe joints and brake equipment devices.

The report was signed by C. H. Weaver, New York Central, (chairman); W. W. White, Michigan Central; H. A. Clark, Soo Line; E. Von Bergen, Illinois Central; C. B. Miles, New York Air Brake Company, and R. E. Miller, Westinghouse Air Brake Company.

Discussion

It was brought out by one of the members of the committee in discussing the report that the committee has endeavored to stress the need of doing a good mechanical job when installing the mechanical equipment. It was also stated by a committee member that the use of the proposed car testing device did not make any change in the present requirements. It was designed and is now being tried out with the sole purpose of expediting train inspection and thereby relieving terminal congestion. The object of the device is to show the inspector more completely, exactly what he has to do. There was considerable discussion relative to the effect a number of the conclusions and recommendations would have relative to the present A. R. A. rules. It was emphasized that the big problem of the air brake supervisor was to look up the rules and regulations of the railroad by which he was employed. There is no need to conform to the A. R. A. rules or any other when a railroad has rules of its own in effect. The A. R. A. rules establish minimum requirements only.



Standard metal shelfing located at the C., B. & Q. storehouse at Aurora, Ill.

Decisions of the Arbitration Committee

(The Arbitration Committee of the A.R.A. Mechanical Division is called upon to render decisions on a large number of questions and controversies which are submitted from time to time. As these matters are of interest not only to railroad officers but also to car inspectors and others, the Railway Mechanical Engineer will print abstracts of decisions as rendered.)

Responsibility for sprung axle

On January 8, 1924, St. Louis-San Francisco car No. 125310 was repaired by the Cincinnati, Indianapolis & Western at which time R&L No. 2 wheels were changed on account of being slid flat. On January 26, 1924, this same car was again repaired by the C. I. & W., at which time R&L No. 1 and No. 2 wheels were changed on account of slid flat spots. The repairing line stated that the information contained on the original record of repairs was not correct as the bill clerk failed to show the wheel seats out of true but instead showed that the diameters of the wheel seats were 6¼ in. which is not below the condemning limit, but still the axles were scrapped on account of small wheel seats. The repairing line stated further that the wheel seats could not have been repaired without some loss of metal which would have made the seats below 6¼ in., the condemning limit, and for this reason, the wheels were considered as scrap. The owning road based its contention solely on the fact that the handling line's repair card showed that both axles were scrapped on account of small wheel seats while the dimensions furnished in the repair card were within the limits of wear.

The Arbitration Committee referred the case back to the C. I. & W. to describe the condition which required truing the wheel seat. This developed information that the axle was sprung and that, therefore, Rule 84 applies. The decision was that the handling line is responsible.— *Case No. 1458, Cincinnati, Indianapolis & Western vs. St. Louis-San Francisco.*

Labor charges for straightening and repairing metal sills and braces

On April 21, 1923, the Charleston & Western Carolina made repairs to Reading steel hopper car No. 82999 and rendered a bill accordingly. Exception was taken by the Reading to the charge in bulk of 96 hours labor for blacksmith and helper because the repair card did not show what work the 96 hours of labor covered. The only explanation which the Reading was able to secure from the repairing line was that the charge was correct as per Rule 107, Items 439, 440 and 442. The repairing line stated that the metal sills and braces of the car were badly bent and on account of the construction of the car required 96 man-hours in order to do a first-class job of repair.

In rendering its decision the Arbitration Committee stated that "the charge based upon the actual time consumed in straightening and repairing the sills is proper in addition to the charge for the rivets applied (on a rivet basis) in making repairs. The bill, if so rendered, should be paid."—*Case No. 1459, Reading Company vs. Charleston & Western Carolina.*

Subsequent renewal of new wheels within thirty days

On March 30, 1925, the Chicago & North Western applied a new pair of wheels, R&L No. 1, to PARX car No. 513 on account of cut journals (Union Pacific responsibility). As the removed wheels were second-hand, a charge of $15.70 was made against the owner. On April 17, 1925, the Union Pacific removed this same pair of wheels on account of cut journals (Chicago & North Western responsibility) and applied a new pair of wheels for which the owner was charged $15.70, representing the difference in value between the new wheels applied and the second-hand ones removed. The Producers & Refiners Corporation contended that the cost of one pair of wheels, under the principle outlined in decisions rendered in Arbitration Cases No. 1371 and No. 1372, should be jointly assumed by the C. & N.W. and the U.P. for the reason that the last pair of wheels removed had been under the car but 17 days and that the defect card issued by the Union Pacific for wheels removed by the C. & N.W. on March 30 makes the U.P. jointly responsible with the C. & N.W., which road issued its defect card to cover the wheels applied by the Union Pacific on April 17. The C. & N.W. contended that while it was responsible for the second change of the wheels, it was not responsible for the first change and therefore, the rulings, rendered in the first cases can not be applied. The U.P. contended the charge for the subsequent exchange of wheels is not subject to cancellation under Interpretation 11 of Rule 98 as the initial application of the wheels and charge therefor was not made by the U.P.

The Arbitration Committee ruled that Interpretation No. 11 of Rule 98 applied and that the charge against the owner by the Chicago & North Western for the difference in value of the wheels exchanged March 30, 1925, should be withdrawn.—*Case No. 1460.—Producers & Refiners Corporation vs. Chicago & North Western.*

Car damaged due to locomotive derailment

On September 24, 1925, Chicago, Rock Island & Pacific car No. 250030 which is a wooden box car of 80,000 lb. capacity, built October, 1902, with metal draft arms, making it Class E under Rule 112, had all longitudinal sills broken while on the Reading lines. This car was the eighteenth from the head end of a train of 57 cars and buckled due to a sudden stop when the leading engine struck a piece of timber lying across the rail on a curve, derailing the front truck wheels. No cars in the train were derailed and there was no damage other than that stated above. The car was repaired and restored to service.

The Arbitration Committee stated that the handling line is responsible, as per Rule 32, Section (a).—*Case No. 1461—Reading Company vs. Chicago, Rock Island & Pacific.*

Time limit governing charge for weighing

On October 7, 1924, the St. Louis-San Francisco reweighed and remarked car LW No. 33848, as the old date on the car was October, 1923. The Southern Pacific lines in Texas and Louisiana took exception to the charge, contending that the old weight was not out of date as per Paragraph C, Rule 30, which provides that wooden and steel underframe cars, except refrigerator cars, should be reweighed and remarked once every 12 months during the first 24 months a car is in service and thereafter reweighing and remarking may be done after the expiration of 18 months.

The Arbitration Committee sustained the contention of the Southern Pacific Lines.—*Case No.* 1462—*Southern Pacific vs. St. Louis-San Francisco.*

Monthly car repair bill should be carefully checked before rendition

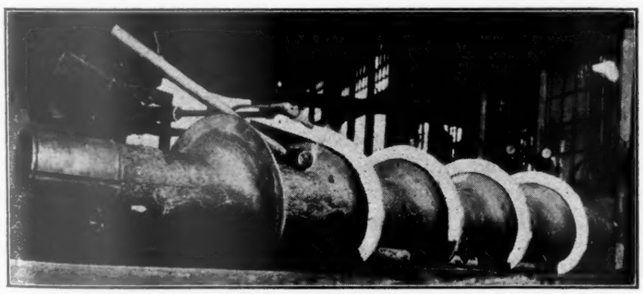
The monthly car repair bills as rendered by the Chicago, Milwaukee & St. Paul were objected to by the Chicago, Burlington & Quincy on the grounds that the supplementary regulations as referred to in Rule 6 were not complied with in their entirety. The specific point in question was paragraph 3 under sub-heading B, Preparation of Monthly Bills, both on the bottom of page 12 and the top of page 13 of the Regulations. It was claimed that the C. M. & St. P. did not make a detail check of its bills before rendering to eliminate all duplicate charges for journal bearings as per Rule 99 and duplicate charges for cleaning air brakes on the same car within 60 days as per Rule 60. The C. M. & St. P. contended that the majority of the roads follow the same practice and believe that the supplementary regulations, so far as the section covering this disputed point was concerned, were not mandatory but simply recommendatory, or rather, an ideal practice. The contention of the C. B. & Q. was that all sections of the supplementary regulations are mandatory and if not complied with it has the right to recheck such bills on the ground that they are not made up according to the rules.

The Arbitration Committee ruled that "the monthly bills must be checked by the road rendering them against improper charges of this character."—*Case No.* 1463—*Chicago, Milwaukee & St. Paul vs. Chicago, Burlington & Quincy.*

Repairing stoker and elevator screws

By F. P. Deissler

PRACTICALLY all the larger railroads have locomotives equipped with stokers and I have noted in past issues of the *Railway Mechanical Engineer* that there is a considerable difference in the methods used by many of these roads in the repairing of stoker elevator screws. Quite a number of the locomotives on the road with which the writer is connected are equipped with stokers and we have experimented to a considerable degree with different methods of repairing them. We have found that there is a considerable saving in placing them in condition for further use. The life of these screws depends entirely on the wearing qualities of the screw shaft.



Tacking and shaping the bar to the edge of the screw

When the blade of the screw becomes worn we electrically weld a ¼-in. by 1¼-in. bar to the edge of the worn blade. In preparing the screw for welding, the screw is first thoroughly sanded to remove all coal tar and rust; the end of the ¼-in. by 1¼-in. bar is then tacked to the blade by means of the electric arc and the bar is then heated 5 in. or 6 in. ahead of the weld with an acetylene torch. It is then bent edgewise and hammered down to fit the curve of the blade and tacked. This operation is repeated for the entire length of the screw. After the work of tacking and fitting the bar to the blade has been completed, the operator finishes the welding.

When the screws are considerably worn at the edge, we let the bar extend over the edge of the screw, as shown in the illustration, to give it the proper dimension. After the welding has been completed no further machining or finishing is required. We have followed this practice for some time and have as yet to discover a failure. This method practically brings the blades to the original dimensions and gives just as efficient service as a new screw.

Old truss rods used for straightening center sills

IN straightening center sills, when rebuilding several hundred of the Denver & Rio Grande Western freight cars at Denver, Col., turnbuckles, like the one shown in the illustration, proved very useful. They are made from old truss rods by cutting them off a few inches each side of the buckle and bending the ends to hook over the flange of the center sills. By placing one or more of these buckles over the straight parts of the sills and tightening them up with a bar, the bulged portions may be quickly pushed out straight with a jack, while the straight parts are held in position. Another advantage of these turnbuckles is that the flame of a blow torch may be turned close to them without seriously affecting the threads.

A handy device for straightening center sills

The Reader's Page

Have You a Question? Ask it
Have You an Opinion? Express it

Substituting cast steel yokes wrong repairs

McKees Rocks, Pa.

To the editor:

A question was asked in the May, 1927, issue as to whether or not the substitution of a cast steel coupler yoke for an A. R. A. standard yoke would constitute wrong repairs, and what A. R. A. rule would apply in such a case. This question was answered by J. B. Searles in the June issue, in which he stated that Rule 88 would apply.

Under index C, page 38, of the Manual of Standards and Recommended Practices, a wrought iron yoke 1¼ in. by 5 in. is shown as the A. R. A. standard. We have a complete set of pages in our manual, but we are not able to find a page showing a cast steel yoke as an A. R. A. standard. Rule 17 allows an A. R. A. standard to be applied in place of a non A. R. A. standard, and does not say a defect card must be applied when applying an A. R. A. standard.

For our information I would like to know if there is an A. R. A. standard cast steel yoke.

Wm. S. Elder.

(No standard cast steel yoke has ever been adopted by the A. R. A. The rules specifically state that the original plan of construction of the car must be followed. Substituting a wrought iron A. R. A. standard yoke for a cast steel yoke does not authorize a defect card according to Rule 17. On the other hand, it is evident (see Rule 114) that no allowance should be made for betterments in case a cast steel yoke was substituted for an A. R. A. standard yoke, assuming that the application of a yoke not standard to the car would not be authorized by the car owner. Mr. Searle's answer is believed to be correct, that a defect card for labor only should be issued. —Editor.)

Guesswork in locomotive operation

Paragould, Ark.

To the editor:

From the data set forth in your editorial in the May issue of the *Railway Mechanical Engineer*, entitled "Guesswork in locomotive operation," it would seem that the application of gages in the locomotive cab, indicating the initial and cylinder back pressures, would be highly profitable if applied generally on locomotives. The writer fully recognizes that the human factor plays an important part in the proper handling of locomotives and if it is possible to eliminate this human equation by the introduction of automatic devices, such as an automatic cutoff control, a considerable saving would be obtained.

Generally speaking, neither mechanical officers nor enginemen ever make a complaint to the enginehouse foreman as long as the exhaust has a regular beat. Too often they lose sight of the fact that the exhaust pulsations may be of the same exactitude as the tick of a ship chronometer, and still, the valves may not be functioning properly.

Pinching a modern locomotive over to adjust the valves, or what is know in enginehouse parlance as "trailing the engine over" when the valves are reported "out," is a hard job in any enginehouse. But that is not the worst. There is hardly a steamship plying the seas, equipped with reciprocating engines, on which the steam engine indicator is not considered a necessary adjunct in making proper valve adjustments and keeping the engines tuned. Diagrams are taken daily, and when the ship reaches the home port, the cards are forwarded to the shore engineer. These cards furnish him with the information that enables him to keep better advised as to the daily operating conditions of the engines on each ship.

While I fully realize that the steam engine indicator could not receive such general use on locomotives, yet I believe a periodical use of this little instrument on different divisions would not only save fuel, but also show in many cases why some locomotives of the same class are harder on the driving boxes and rod brasses than others, poor steamers, etc.

L. Showell.

Cutting steam hose bolts is not economical

Chicago.

To the editor:

The device for cutting steam hose bolts described on page 216 of the April issue of the *Railway Mechanical Engineer* while interesting, is open to some comment. The statement is made that the old method of removing the nuts with a wrench was "too slow," making the old bolt cost more than a new one.

I believe, as regards the air hose bolts, this statement is correct, but let us look at the question of the steam hose bolts. The cost of these is approximately one cent each. I understand by the method described 480 of these can be cut per hour, which would be $4.80 per hour lost if all the hose were found to be fit for re-applying.

We find 95 per cent are quite satisfactory for further use and by a small air operated wrench device, 216 bolts can be removed per hour, including rejection of the five per cent mentioned. The serviceable bolts are dropped into a pan of graphite oil and left a few hours before re-using. Thus, instead of scrapping $4.80 worth of good bolts, not taking into account the five per cent possible defective, we are saving $2.16 worth of material.

"Bill Brown."

Locomotive cylinder mechanical lubricator

THE cylinders of steam locomotives are now lubricated by means of mechanical or hydrostatic lubricators which function by releasing, from time to time, a drop of special oil into the steam before it enters the valve chamber. This oil must have the property of blasting itself into small particles which are sustained in the steam in a state of colloidal suspension. The steam deposits some of the oil on any surfaces with which it comes in contact, such as the steam pipes, the valve chambers, the port passages, the cylinder heads, the piston heads and finally the cylinder walls. The advent of high steam temperatures made this method of lubrication somewhat more difficult. It seems desirable to deposit the lubricant on the cylinder walls when the temperature is at its lowest point. This led the Baltimore Oil Engine Company, Eastern avenue and Thirty-first street, Baltimore, Md., to develop under the Wygodsky patents a new method of lubrication of the steam cylinders, which is designated as the Boec system of direct spraying of the lubricating oil on the cylinder walls. The device is sold and serviced by the E. A. Lundy Company, Fulton Building, Pittsburgh, Pa.

The principle of the direct spraying of the lubricant into the cylinders is illustrated in Fig. 1. An oil atomizer which is located in each back cylinder head in such a position that a hollow cone spray forced in under 2,000 lb. per sq. in. pressure, intersects the cylinder walls.

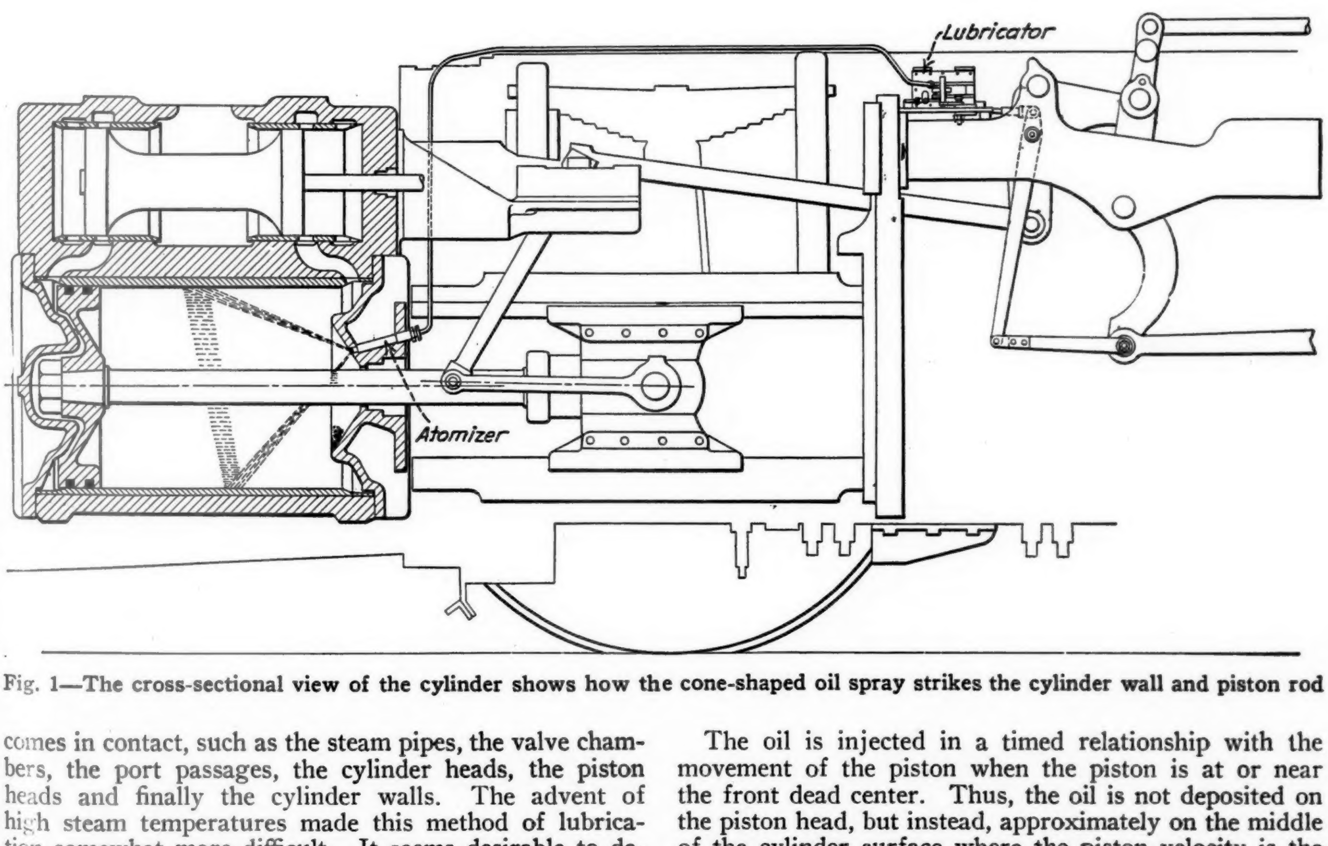


Fig. 1—The cross-sectional view of the cylinder shows how the cone-shaped oil spray strikes the cylinder wall and piston rod

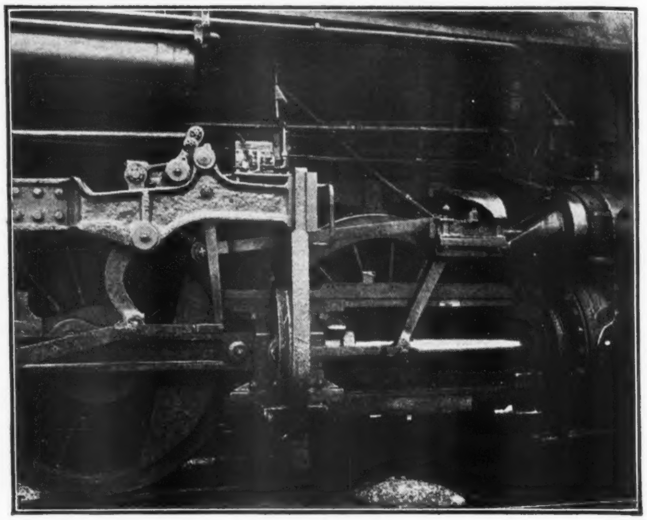
The oil is injected in a timed relationship with the movement of the piston when the piston is at or near the front dead center. Thus, the oil is not deposited on the piston head, but instead, approximately on the middle of the cylinder surface where the piston velocity is the highest, and therefore, where the oil is most needed. The oil is injected at the period when the steam is exhausting from the rear exhaust port. At this point in the steam cycle the cylinder walls and contents are at approximately their lowest temperature. Only a small percentage of the oil mixes with the steam, the high

velocity with which it is driven into the cylinder carrying most of it directly to the cylinder walls to which it adheres. Sufficient oil is picked up and carried by the steam to lubricate the valve chamber bushings and the valve stem. The oil is injected intermittently, say once in 30, 40 or 100 revolutions of the locomotive driving wheels, depending on the class of service.

The atomizer in the back cylinder head consists of a hollow stem valve with a mushroom head, which is opened by each 2,000-lb. oil pressure impulse and seated again by the action of a heavy coil spring around the valve stem. The travel of the valve is controlled by an adjustable collar on the inner end of the valve stem. Just back of the mushroom head are six tangential holes which lead into the hollow stem through which the oil is fed. When the valve is forced open by the oil pressure, oil is forced through the six holes into the space between the valve and its seat, which is so proportioned that the spray issues in hollow cone form.

Several sectional views of the lubricator proper are shown in Fig. 2. Referring to Section *A-A,* one end of the primary plunger is attached to a crosshead in which is located a rack and pinion. The pinion is oscillated one for each revolution of the locomotive wheels and each oscillation completes a double stroke of the plunger. The primary plunger draws oil through a double filter, up through the suction valve and delivers it through a discharge valve into a chamber above a comparatively large discharge piston, thus causing the discharge piston to recede slightly with each stroke of the primary plunger. At the same time some of the oil from the primary plunger is fed through to a chamber above a small secondary plunger, section *C-C,* which is connected to and recedes with the large discharge piston.

Located in the end of discharge piston stem is a pin which acts against a spring. After a given number of the swinging bracket, opens an oil air valve which admits compressed air from the brake system to the lower side of the discharge piston. At the same time an oil return valve is opened to permit the unrestricted flow of



The Boec lubricator applied to a Mikado locomotive

oil from the chamber above the discharge valve, back to the reservoir. Owing to the differential in the diameters of the discharge piston and the secondary plunger, above which a small volume of oil is now trapped, 90-lb. air pressure develops 2,000-lb. oil pressure and the upward movement of the secondary plunger forces a small amount of oil through the discharge pipe to the atomizer, at this pressure. With the end of the discharge piston stem removed from the trigger, it is returned to

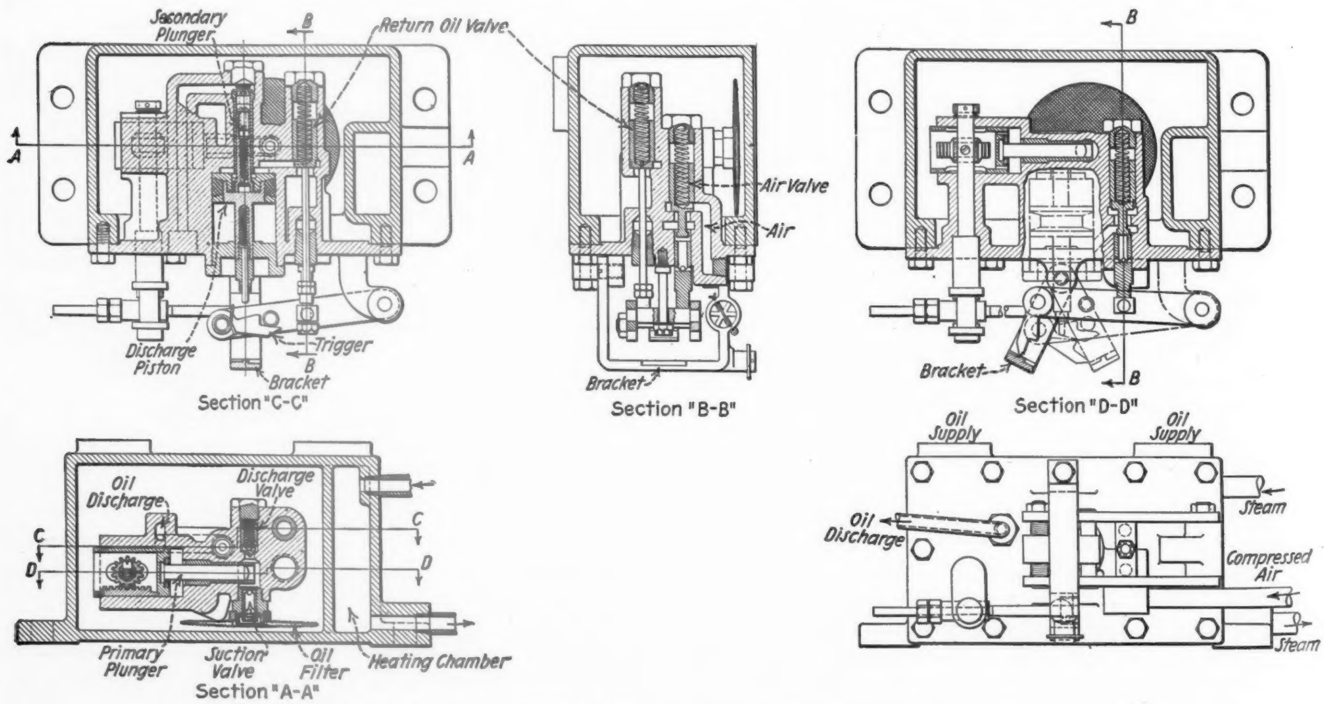


Fig. 2—Sectional views of the Boec locomotive cylinder lubricator

revolutions of the driving wheels, depending on the feed adjustment, this pin is pressed against a trigger, section *C-C,* the end of which is ultimately moved down until it engages a tooth on an oscillating bracket as shown in Section *D-D.* The toggle action of the trigger and the link to which it is attached, caused by the trigger with normal position by a coil spring. The use of air for discharging the oil makes it possible to produce the same character of spray irrespective of the speed of the locomotive.

Another feature of the lubricator is that it is possible, before starting on a trip, to lubricate the cylinders manu-

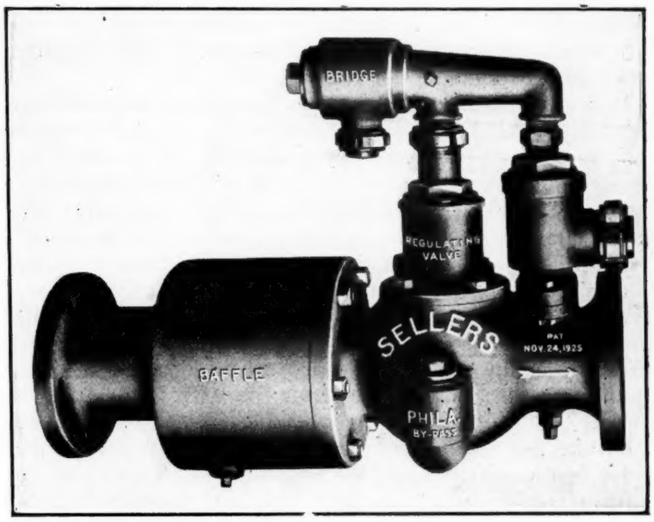
ally. This enables the engineman to check up the working of the lubricator as well as to fill the oil pipe connecting the lubricator with the atomizer. The lubricator is provided with a steam chamber for heating the oil. Experience has proven that it is not necessary owing to the high hydrostatic pressure and the fact that the atomizers are located in the back cylinder heads.

One of the illustrations shows the Boec lubricator as applied on a Mikado type locomotive. After six months service, the cylinder walls were examined and found to be covered with an evenly distributed film of clean lubricant and not with the usual muddy oil. The valve chambers and valve stems were also found to be adequately lubricated.

Sellers exhaust feedwater heater injector

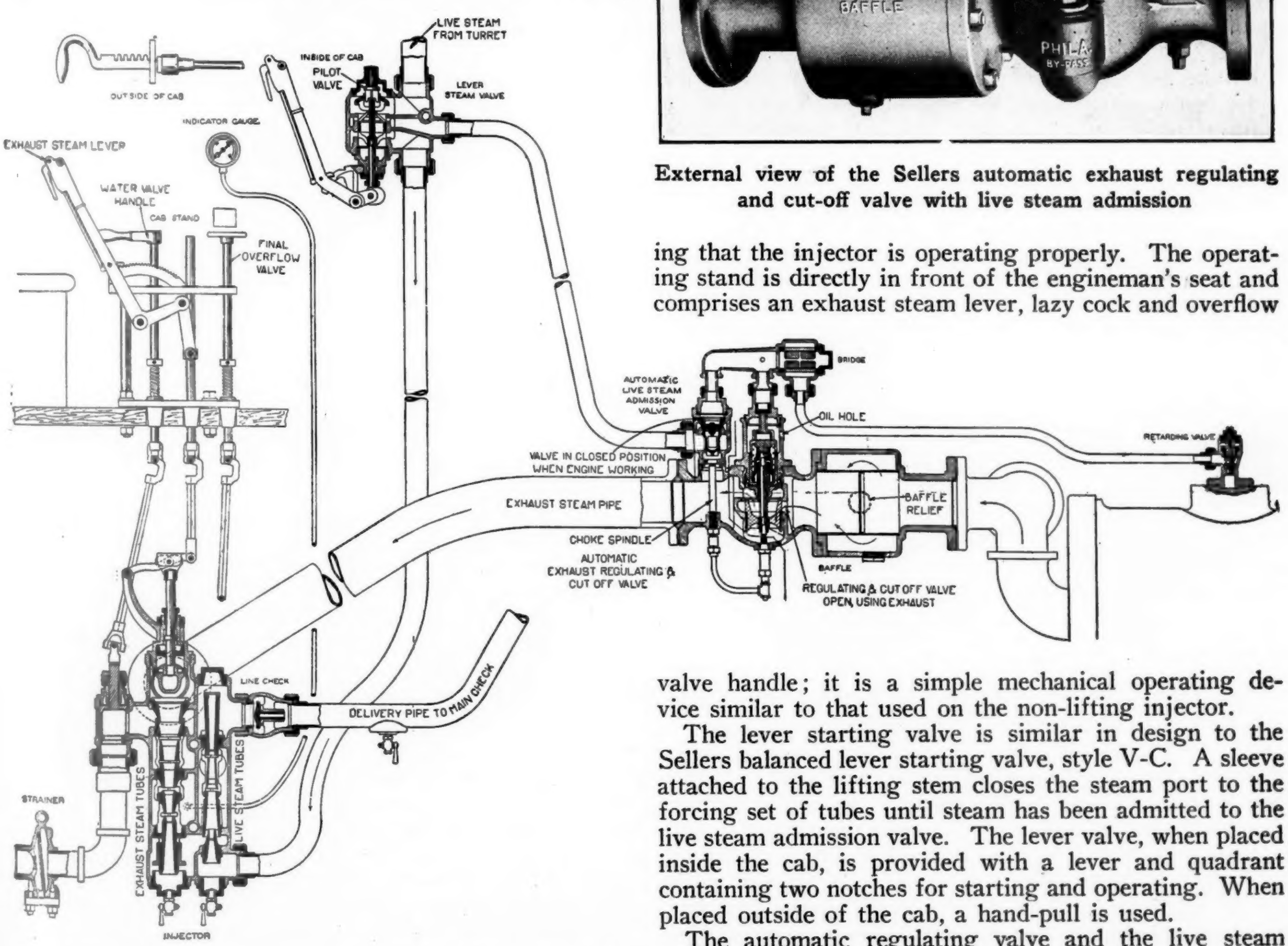
THE exhaust feedwater system designed by William Sellers & Company, Inc., 1600 Hamilton street, Philadelphia, Pa., consists of an injector with a set of low-pressure tubes with an exhaust steam nozzle of large diameter, delivering under pressure to a set of forcing tubes operated by steam from the boiler. The energy or heat contained in exhaust steam is a large proportion to that contained in steam at 200 or 250 lb. pressure, and it is this latent heat which is applied usefully to heat and forces a strong jet of water into the second set of nozzles. By this method, a large amount of the exhaust steam may be used, while all the heat taken from the boiler by the live steam tubes is returned to the boiler without subtraction from the available heating capacity of the exhaust.

Between the two sets of tubes is placed a check valve; steam or water from the forcing set of tubes cannot pass back into the exhaust delivery chamber, water supply, or exhaust pipe. An indicator or vacuum gage is connected to the overflow chamber of the exhaust nozzles. When the correct proportions of water and steam are admitted, a partial vacuum is shown on the gage indicat-



External view of the Sellers automatic exhaust regulating and cut-off valve with live steam admission

ing that the injector is operating properly. The operating stand is directly in front of the engineman's seat and comprises an exhaust steam lever, lazy cock and overflow



The general arrangement on the locomotive of the units and pipes of the Sellers exhaust feed water heater injector

valve handle; it is a simple mechanical operating device similar to that used on the non-lifting injector.

The lever starting valve is similar in design to the Sellers balanced lever starting valve, style V-C. A sleeve attached to the lifting stem closes the steam port to the forcing set of tubes until steam has been admitted to the live steam admission valve. The lever valve, when placed inside the cab, is provided with a lever and quadrant containing two notches for starting and operating. When placed outside of the cab, a hand-pull is used.

The automatic regulating valve and the live steam admission valve maintain constant operating conditions for the injector. These valves are contained in one body, upon which are placed two cylinders connected

by a bridge for steam admission to both pistons at the same time. The automatic regulating valve is open to admit exhaust steam to the injector when the engine is under load, but is balanced to regulate automatically its admission port in proportion to the variation of exhaust pressures. It automatically closes when the engine stops, so that steam from the boiler admitted through the live steam admission valve cannot pass to the exhaust ports of the cylinders.

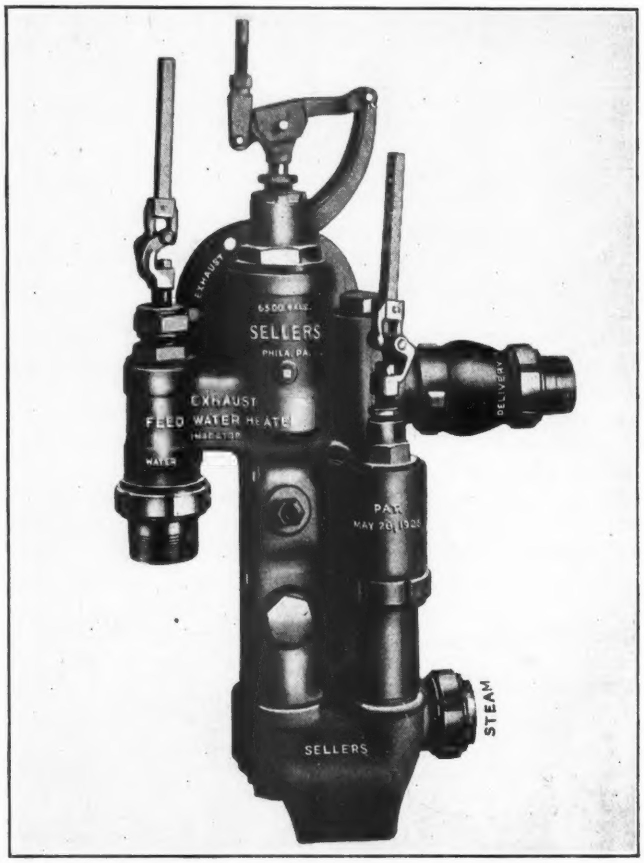
These valves operate when the locomotive throttle is opened to admit steam to the steam chest; steam flows into the bridge and forces both pistons down, opening the exhaust regulating valve and closing the live steam admission valve by pressure on differential areas. If the locomotive throttle is closed when the injector is feeding, the pressure within the bridge is relieved, the pistons above each valve move upward, close the exhaust valve and open the live steam admission valve, to give a continuous flow of live steam to the exhaust nozzles at approximately the same pressure as previously supplied from the cylinders.

It is obvious that if both the live steam and exhaust regulating valves act at the instant the throttle is open and in advance of any supply of exhaust steam from the cylinders, the injector would be without steam until the locomotive was in motion. It is, therefore, advantageous to delay the action of both of these valves until there is sufficient movement of the engine to get a full supply of exhaust steam. This is done by the retarding valve placed at the forward end of the supply pipe to the bridge. It is a simple device provided with a small opening for flow toward the bridge and a quick opening to the exhaust to permit the valves to return to normal condition.

By the use of these devices, the injector will feed the boiler continuously when the engine is standing, hauling a train, or drifting; in fact, entirely independent of the position of the locomotive throttle, permitting the same functions as the usual non-lifting injector.

The method of operation is simple: If the locomotive is under load, the water valve is opened and the lever of the cab stand is drawn back until the indicator registers; the balanced lever starting valve is then opened and the overflow closed. When the engine is standing, the action is the same, except the preliminary opening of the lever valve one notch.

The amount of exhaust steam that can be used is fixed by the feed temperature limit of the forcing set of tubes; the colder the water in the tank, the greater the proportion of exhaust steam that may be used and the higher the relative efficiency of the apparatus; if the water supply is 45 deg. more exhaust steam can be used than when the water supply is 85 deg. Regulation of the exhaust steam supply is obtained by adjusting the position of the lever of the cab stand to give the required discharge area of the exhaust steam nozzle. The indicator gage instantly tells the engineman if the lever is in the right position. Careful enginemen will draw back the lever to admit as much exhaust as possible to induce the greatest economy. For the same reason the amount of steam passing through the live steam admission valve should be increased by hand adjustment during the winter months, when the water is colder, for the pressure within the injector exhaust supply pipe should be approximately the same with live or exhaust steam.



The Sellers exhaust steam injector

The Sellers system is applicable to high pressure, 200-250 lb., freight and passenger locomotives. The tubes, nozzles and all wearing parts can be removed without disconnecting the injector or valve bodies.

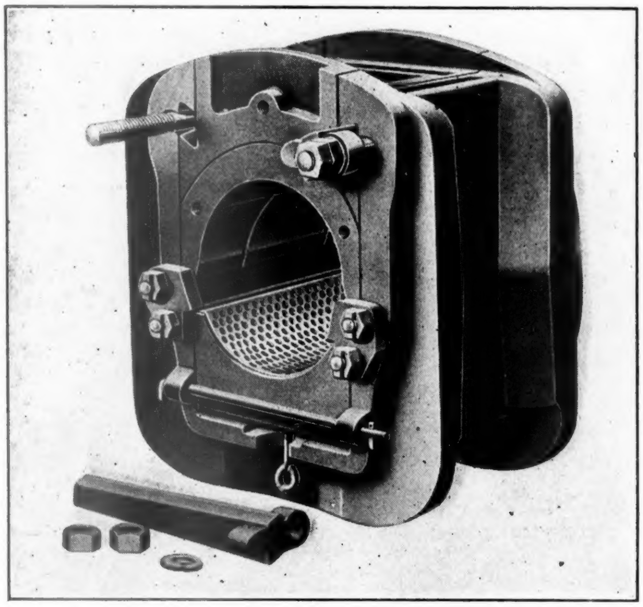
Live steam from the boiler cannot be used by the enginemen for operating the exhaust heater tubes of the injector when exhaust from the cylinder is available.

Franklin locomotive driving box

ORDINARILY, the removal of a driving box brass or the relining of a hub face involves the removal of the side rods and the dropping of the wheels. With the advent of the driving box now marketed by the Franklin Railway Supply Company, Inc., 17 East Forty-second street, New York, this work can be eliminated. The conventional driving box has the sides and the top cast integral. The bottom is open and contains a separate removable lubricating cellar. The bearing is forced into the box under heavy pressure. Since it is impracticable to provide a bearing surface on the removable cellar, such a box has a break in the bearing surface between the hub face and the driving wheel. This undesirable feature is remedied in the Franklin driving box by coring out the bottom portion of the box to form a receptacle for the lubricator and leaving the outer or hub wall solid, which together with the bearing and retainer forms a complete circular bearing for the hub face of the wheel. This hub face is lined with bronze, thus improving the bearing surface.

In order to remove the bearing or to reline the hub face of the ordinary driving box, the wheels and axle

must be dropped and removed. With the Franklin driving box the bearings are readily renewable and the entire driving box may be removed from the locomotive without disturbing the wheels. The two sides and bottom of the box are integral as opposed to the two sides and



The crown brass and hub liner of the Franklin driving box may be renewed without removing the side rods or dropping the wheels

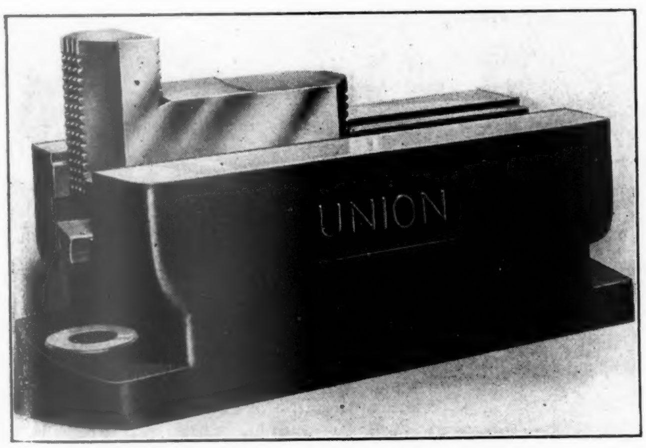
top of the customary design. The bearing of the box is somewhat similar in shape to the ordinary crown bearing but has flat sides which fit between the vertical members of the box. The bearing is held in place by a bearing retainer which rests on the bearing and transmits thereto its proportion of the weight of the locomotive. This retainer and the bearings are clamped together and held immovable by two tapered wedges, the bearing surfaces of which are shaped to lock the different parts firmly together.

The bottom portion of the box is cored out to form a receptacle for the lubricator. The outer or hub wall of the cavity is solid, forming with the bearing and retainer a complete circular bearing for the hub face of the wheel. Abutments are provided on the inner end of the box to prevent an endwise movement of the bearing. On the top of the bearing is a ridge which fits into a corresponding groove out into the bearing retainer. This prevents any end movement of the bearing retainer. This interlocking makes the construction equivalent to an integral box, bearing and cellar.

The lubricator used is of the standard type except that the grease container has no end wall on the hub side. The end wall is unnecessary because its equivalent is cast integral with the box. This construction makes it possible to remove the grease container to inspect the grease cake without disturbing the other lubricator parts. The lubricator is provided with one indicator only, on the inside of the box so that the lubricator can be withdrawn entirely from the box for refilling or inspection. This is easily done by taking out the single retaining pin that holds the lubricator in place.

Face plate and boring mill jaws

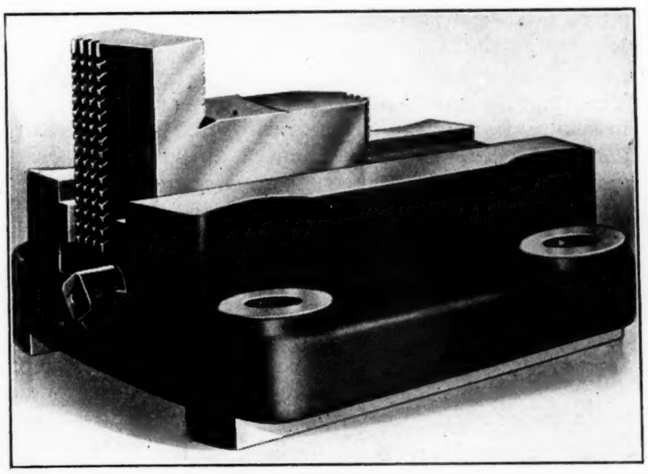
THE illustrations show a face plate and boring mill jaw made by the Union Manufacturing Company, New Britain, Conn. The face plate jaw, which is reversible and interchangeable, is made in two styles, the No. 48 having a body of iron construction and the No. 72, a body of steel construction. The jaws are made from hardened and heat-treated steel. The operating screws



The Union face-plate jaw made with an iron body

are extra large and protected from dust and chips by long jaws. The 6-in. to 14-in. sizes are suitable for face plates from the smallest in diameter up to the largest machines built.

The boring mill jaws are also made in two styles and are reversible and interchangeable. They are designed with 1-in. parallel ribs spaced 6 in. centers to fit the parallel slots in the table of most boring mills. The sliding jaws are extra long to cover the operating screws. The jaws are made in sizes ranging from 6 in. to 14 in. The 14-in. size had six bolts.

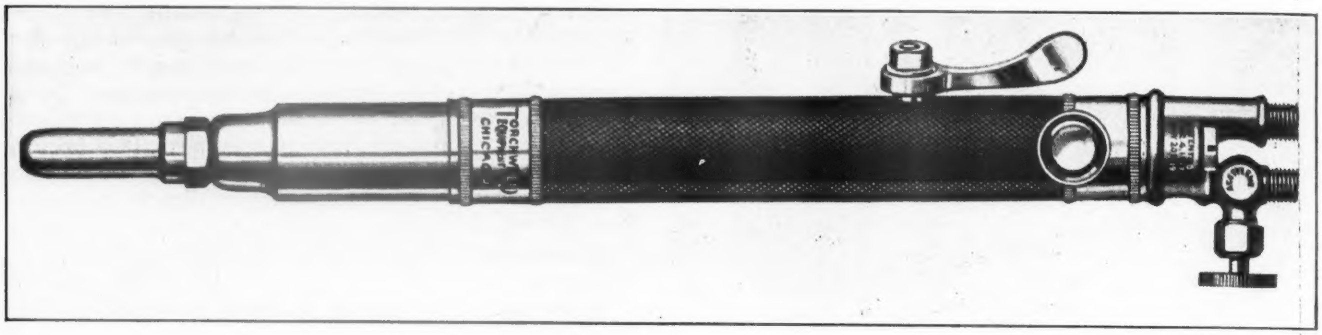


The Union steel boring mill jaw

Draw-cut machine tools.—Heavy duty draw-cut machine tools, special machinery for contract shops, finished machine keys and Robinson automatic air hose couplings for pipe and hose lines are described and illustrated in a bulletin issued by the Morton Manufacturing Company, McKinney avenue and Hoyt street, Muskegon Heights, Mich.

Non-flash machine cutting torch

A NON-FLASH cutting torch, designed for use with machines for the cutting of various shapes, bevel and heavy work, whether such machines are mechanically driven or operated by hand, has been placed on the market by the Torchweld Equipment Company, 224 North Carpenter street, Chicago. The construction of the torch includes the Torchweld patented non-flash features and a safety back pressure valve. The principal parts are made from special metal, die-pressed and from solid bar brass stock. All permanent joints are brazed.



The Torchweld non-flash machine cutting torch, Style No. 2550

This torch will remain steady in operation because the gases for the preheating flames are thoroughly mixed and one cannot be rarified against the other as the mixture is effected beyond the heat of the work. The oxygen gas passage for cutting is large and free from obstruction or angular resistance, enabling all cutting to be done with the lowest practicable pressure on the oxygen line.

The straight design of the torch facilitates setting it at any desired angle to meet requirements and easily clamping it to the machine. The tips are of two-piece construction. The standard internal cutting tips and nozzle sleeve are suited for average cutting operations. The foundry type internal cutting tips and nozzle sleeve provide for the heavier automatic cutting. The torch and tips operated with acetylene, hydrogen, carbo-hydrogen or Butane and other fuel gases used with oxygen.

Torchweld gas pressure regulator

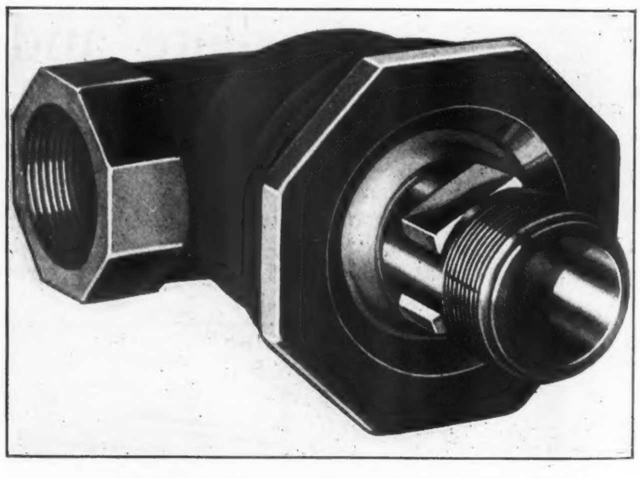
THE Torchweld Equipment Company, 224 North Carpenter street, Chicago, has placed on the market a redesigned gas pressure regulator which can be furnished for every kind of gas used in welding and cutting operations. The regulator is sturdily built and made from die-pressed metal. It has a minimum of accurately fitted working parts that are locked in alinement. The regulator has self-centering sensitive triple diaphragms which are interlocked in position between the regulator hood and the body. The parts of the unit are easily accessible for quick adjustment. The regulator has been approved by the Underwriters Laboratories.

Chicago, Rock Island & Pacific.—Plans are in the course of preparation for the construction of additional locomotive repair shop facilities at Silvis, Ill., estimated to involve a total expenditure for buildings of $125,000.

Flexible metallic joint for steam lines

THE Vapor Car Heating Company, Inc., Railway Exchange, Chicago, has developed a flexible metallic joint for use with steam lines in passenger yards, railway stations, enginehouses, etc. This joint incorporates the same principle used in the flexible joints of this company's metallic car conduits—no weight or wearing strain is carried by the gasket. It is made in various sizes from ¾ in. to 1½ in., with full pipe size opening throughout and without restriction in the path of the steam.

These joints are furnished in either a straight or right-angle type to meet the varying requirements for assembling the steam pipe line. The joint is constructed and assembled in such a way that condensation drains freely from the connection after the steam has been shut off in the valve. This feature prevents the possibility of freezing the connections.



Angle type flexible metallic joint for steam lines

Concidal fans.—A brief description of the advantages in design and characteristics of Buffalo double-curved blade fans, as well as information on their application to heating and ventilating service, is contained in Catalogue No. 422 issued by the Buffalo Forge Company, Buffalo, N. Y.

Cincinnati standard arbors.—"Putting quality plus in Cincinnati standard arbors" is the title of a new publication issued by the Cincinnati Milling Machine Company, Cincinnati, Ohio. The pages of this publication tell about Cincinnati arbors, about the special department in which they are made, and the special tools for testing them. Specifications, code words and prices also are given.

News of the Month

PROMOTIONS AND APPOINTMENTS — THE SUPPLY TRADE — CLUB AND ASSOCIATION NEWS — NEW TRADE PUBLICATIONS — NEW SHOPS

A FIRE at the Allegheny shops of the Baltimore & Ohio at Pittsburgh, Pa., on April 26, damaged the blacksmith shop, saw mill and enginehouse; estimated total damage $100,000 or more.

CLARENCE ROBERTS, assistant road foreman of engines of the Pennsylvania, has been appointed a member of the Executive Committee of the International Railway Fuel Association, succeeding E. E. Chapman, of the Santa Fe, who has resigned. Mr. Chapman has been appointed a member of the Advisory Committee.

APPRENTICES of the mechanical department of the Atchison, Topeka & Santa Fe have compiled and issued the "Iron Horse," a volume summarizing all apprentice activities for 1926. It calls attention to the fact that 242 supervisory officers in the mechanical department of the Santa Fe, including an assistant to the vice-president, eight division master mechanics and 16 enginehouse foremen, are graduates of the apprentice school.

American locomotives demonstrate serviceability in South Africa

Operation and maintenance costs of American locomotives operated in the Union of South Africa compare favorably with other makes, and savings effected by their use is expected to influence increased purchases, according to reports reaching the Department of Commerce.

Discussing the relative merits of the several makes of locomotives operated in the Union of South Africa, the Minister of Railways is quoted as saying in a recent session of Parliament that locomotives built in the United States had shown a large saving compared with other locomotives operated in South Africa.

C. & A. apprentices' school

The Chicago & Alton recently opened a school for apprentices at its shops at Bloomington, Ill. The 62 apprentices who have registered for the course have been divided into classes of 14 pupils each, to receive two hours of instruction one day each week. The students are given a fundamental training in mathematics, letter writing and drawing. Other compulsory subjects are mensuration, lathe work, steam locomotion, geometical drawing and hydrostatics. Each day apprentices from each department make up the class of 14. On the first day there were four machinist apprentices, four boilermaker apprentices, one painter apprentice, one airbrake worker, one electrical worker, one coach shop apprentice and one wood worker. Upon the completion of the course diplomas will be awarded.

Change in rule for settlements for rebuilt cars proposed

The Interstate Commerce Commission on June 4 made public a proposed report by the director of its Bureau of Service, William P. Bartel, recommending a finding by the commission that interchange rule No. 112 of the American Railway Association is unreasonable in so far as it affects settlements to be made between railroads for rebuilt freight cars when badly damaged or destroyed. The report was made in No. 17,849, Bangor & Aroostook v. American Railway Association et al.

"The commission should find." Director Bartel recommends, "that as to past and future a rebuilt freight car is one which the carrier was or is required by the accounting rules of the commission to record in equipment investment account. The commission should find that for freight cars rebuilt in the future, the proposed rule formulated by the special committee on rebuilt cars, which contemplates settlement for cars of classes 'A' and 'D' on basis of 80 per cent of reproduction cost new, less depreciation from date rebuilt, will be reasonable. As to freight cars reconstructed in the past, the commission should find that the present rule is unreasonable and that for the future a rule which provides for settlement for cars in classes 'A' and 'D' on basis of 80 per cent of reproduction cost new, less depreciation from date rebuilt, and cars of classes 'E-1' and 'E-2' on basis of 70 per cent of reproduction cost new less depreciation from date rebuilt, will be reasonable."

Under the present rule the settlement price is based on present value, commonly referred to as the present cost of reproduction new less depreciation, computing depreciation from date of original construction.

The "Century's" 25th birthday

The 25th anniversary of the Twentieth Century Limited—twenty-hour train of the New York Central between New York and Chicago—occurred on June 15 and, to celebrate the event, the railroad company issued a handsome pamphlet, lettered in silver, containing six full-page colored reproductions of the six notable paintings which have been used on the calendars of the road for the past six years, showing this train in different situations.

In 1902, the "Century" was made up of three sleeping cars, a smoking car and a dining car, and on the first trip, westbound, the number of passengers was only 27. At the present time, an average of three trains of ten cars each are run each way daily, and the annual gross earnings of the train are about $10,000,000. The cost of the first train of five cars and one locomotive was about $115,000; and 21 cars and seven locomotives, then in service, cost about $525,000. In service on these trains today are 87 sleeping cars, 15 observation cars, 12 club cars, eight dining cars and 24 locomotives—representing a gross cost of $8,000,000.

Meetings and Conventions

1928 Mechanical Division convention

The General Committee of the Mechanical Division of the American Railway Association and the executive committee of the Railway Supply Manufacturers' Association held a joint conference at Montreal when it was decided to hold the 1928 convention at Atlantic City, N. J., in connection with a exhibit by the Railway Supply Manufacturers' Association, June 13 to 20, inclusive. A delegation from Atlantic City assured the committees that the new convention hall would be completed in time to house both the exhibits and the convention.

Steel Treaters and Welding Society to hold combined exposition

The National Steel and Machine Tool Exposition will be held at the Statler Hotel, Detroit, Mich., during the week of September 19 under the auspices of the American Society for Steel Treating. Ninety thousand square feet are available for exhibit purposes this year. The factory equipment exposition will cover everything from steel, raw material, heat treating equipment, small tools, machine tools, forging equipment, inspection, handling and welding materials. Approximately 10,000 sq. ft. will be devoted to welding material and equipment, a new feature of the steel and machine tool exposition. The welding exhibit was

previously an independent exposition under the auspices of the American Welding Society. This year the annual fall meeting of the welding society will be held at Detroit beginning September 19.

The following list gives names of secretaries, dates of next or regular meetings and places of meeting of mechanical associations and railroad clubs.

Air-Brake Association.—T. L. Burton, 165 Broadway, New York.

American Railroad Master Tinners' Coppersmiths' and Pipefitters' Association.—C. Borcherdt, 202 North Hamlin Ave., Chicago.

American Railway Association Division V.—Mechanical.—V. R. Hawthorne, 431 South Dearborn St., Chicago. Next meeting June 13 to 20, 1928, inclusive, Atlantic City, N. J.

Division V.—Equipment Painting Section.—V. R. Hawthorne, Chicago. Convention Hotel Kentucky, Louisville, Ky., Sept. 13, 14 and 15.

Division VI.—Purchases and Stores.—W. J. Farrell, 30 Vesey St., New York.

American Railway Tool Foremen's Association.—G. G. Macina, 11402 Calumet Ave., Chicago. Annual convention, Chicago, August 31, September 1 and 2.

American Society of Mechanical Engineers.—Calvin W. Rice, 29 W. Thirty-ninth St., New York. Railroad Division, Marion B. Richardson, associate editor, *Railway Mechanical Engineer*, 30 Church St., New York.

American Society for Steel Treatment.—W. H. Eiseman, 4600 Prospect Ave, Cleveland, Ohio

American Society for Testing Materials.—C. L. Warwick, 1315 Spruce St., Philadelphia, Pa.

American Welding Society.—Miss M. M. Kelly, 29 West Thirty-ninth St., New York.

Association of Railway Electrical Engineers.—Joseph A. Andrucetti, C. & N. W., Room 411, C & N. W. Station, Chicago, Ill. Annual meeting, Hotel Sherman, Chicago, October 25-28.

Birmingham Car Foreman and Car Inspectors' Association.—P. H. Gillean, 715 South Eightieth Place, Birmingham, Ala. Meeting, second Monday in each month at Birmingham, Y. M. C. A. Building.

Canadian Railway Club.—C. R. Crook, 129 Charon St., Montreal, Que. Regular meetings, second Tuesday in each month, except June, July and August, at Windsor Hotel, Montreal, Que.

Car Foremen's Association of Chicago.—Aaron Kline, 626 N. Pine Ave., Chicago, Ill. Regular meeting second Monday in each month, except June, July and August, Great Northern Hotel, Chicago.

Car Foremen's Association of St. Louis.—F. D. Wiegmar, 720 North 23rd St., E. St. Louis, Ill. Regular meeting first Tuesday in each month, except June, July and August.

Car Foremen's Club of Los Angeles.—J. W. Krause, 514 East Eighth St., Los Angeles, Cal. Meeting second Friday of each month in the Pacific Electric Club Building, Los Angeles Cal.

Central Railway Club.—H. D. Vought, 26 Cortlandt St., New York. Regular meetings second Thursday each month, except June, July and August at Hotel Statler, Buffalo.

Chief Interchange Car Inspectors' and Car Foremen's Association.—(See Railway Car Department Officers' Association.)

Cincinnati Railway Club.—D. R. Boyd, 811 Union Central Building. Regular meeting second Tuesday, February, May, September and November.

Cleveland Railway Club.—F. L. Frericks, 14416 Adler Ave., Cleveland, Ohio. Meetings first Monday each month, except July, August and September at Hotel Hollenden, East Sixth and Superior Ave., Cleveland.

International Railway Master Blacksmiths' Association.—W. J. Mayer, Michigan Central, 2347 Clark Ave., Detroit, Mich. Next meeting, Hotel Lafayette, Buffalo, N. Y., August 16-18, 1927.

International Railway Fuel Association.—L. G. Plant Railway Exchange, 80 E. Jackson Boulevard, Chicago.

International Railway General Foremen's Association.—William Hall, 1061 W. Wabash Ave., Winona, Minn. Annual convention Chicago, September 6-9, 1927.

Louisiana Car Department Association.—L. Brownlee, New Orleans, La. Meeting third Thursday in each month.

Master Boilermakers' Association.—Harry D. Vought, 26 Cortlandt St., New York.

New England Railroad Club.—W. E. Cade, Jr., 683 Atlantic Ave., Boston, Mass. Regular meeting second Tuesday in each month, excepting June, July, August and September, Copley-Plaza Hotel, Boston.

New York Railroad Club.—H. D. Vought, 26 Cortlandt St., New York. Meetings third Friday in each month, except June, July and August, at 29 West Thirty-ninth St., New York.

Pacific Railway Club.—W. S. Wollner, 64 Pine St., San Francisco, Cal. Regular meetings, second Thursday of each month in San Francisco and Oakland, Cal., alternately.

Railway Car Department Officers' Association.—A. S. Sternberg, Belt railway. Clearing Station, Chicago. Annual convention Hotel Sherman, Chicago, August 23, 24 and 25.

Railway Club of Greenville.—Paul A. Minnis, Bessemer & Lake Erie, Greenville, Pa. Meeting last Friday of each month, except June, July and August.

Railway Club of Pittsburgh.—J. D. Conway, 515 Grandview Ave., Pittsburgh, Pa. Regular meeting fourth Thursday in month, except June, July and August. Fort Pitt Hotel, Pittsburgh, Pa.

St. Louis Railway Club.—B. W. Frauenthal, Union Station, St. Louis, Mo. Regular meetings, second Friday in each month, except June, July and August.

Southern and Southwestern Railway Club.—A. T. Miller, P. O. Box 1205, Atlanta, Ga. Regular meeting third Thursday in January, March, May, July, September and November.

Texas Car Foremen's Association.—A. I. Parish, 106 West Front St., Fort Worth, Tex. Regular meetings first Tuesday in each month, Terminal Hotel bldg., Fort Worth, Tex.

Traveling Engineers' Association.—W. O. Thompson, 1177 East Ninety-eighth St., Cleveland, Ohio. Annual meeting Hotel Sherman, Chicago, September 13-16, 1927.

Western Railway Club.—Bruce V. Crandall, 189 West Madison St., Chicago. Regular meetings, third Monday in each month, except June, July and August.

Supply Trade Notes

A. O. Woerner, representative of the Scullin Steel Company, St. Louis, Mo., has been appointed assistant vice-president.

The Interstate Iron & Steel Company, Chicago, will construct a furnace building 129 feet by 145 feet at 11018 Burley Avenue.

Edwin S. Jackman of E. S. Jackman & Co., Chicago, agents for the Firth-Sterling Steel Company, died on May 30 at Santa Barbara, Cal.

William duPont, of Wilmington, Del., has been elected a director and chairman of the executive committee of the Miller Train Control Corporation, Staunton, Va.

The North American Car Corporation has opened a district office at Dallas, Texas, in charge of R. W. Patterson, formerly a representative in the export department at New Orleans, La.

The C. J. Tagliabue Manufacturing Company of Brooklyn, N. Y., has opened a branch factory at 5902 Carnegie avenue, Cleveland, Ohio, in charge of A. R. Anderson, district manager.

Earle M. Harshbarger, who has become associated with the S. K. F. Industries, Inc., New York, where he will handle railroad and engineering sales in the territory east of Pittsburgh, was previously in the service of F. S. Bowser & Co., of Fort Wayne, Ind. He was born in Ladoga, Ind., April, 1887, and attended the public and high schools in that city, later attending Wabash and Purdue Universities. He entered the service of S. F. Bowser & Co., manufacturers of oil storage equipment, in 1915, and after remaining at the home office for three years was transferred to the Chicago office where he was in sales work for two years. He then went to St. Louis as assistant district manager of that territory. For the year that he was at St. Louis he specialized in railroad work. He then returned to the home office as manager of the railroad department where he remained for five years, at the same time being manager of the government sales department. Following that he was appointed district manager of the New York office with special attention to railroad work, a position he held until June 1 of this year.

E. M. Harshbarger

M. S. McNay, formerly sales manager of the Bock Bearing Company, Toledo, Ohio, has been appointed western railway sales representative of S. K. F. Industries, Inc., with headquarters at 1140 W. Washington boulevard, Chicago.

Charles D. Wood, president of the R. D. Wood Company, Philadelphia, Pa., died of heart disease suddenly on June 8, in a room in the Hotel Sherman, Chicago, in the midst of a session of the executive committee of the American Waterworks Association which he was attending.

The Whiting Corporation, Harvey, Ill., has appointed Brazelton, Wessendorf & Nelms, Inc., Houston, Texas, its sales agent for southeastern Texas, and J. F. Shouse & Co., 1197 Starks building, Louisville, Ky., its sales representative for the state of Kentucky and the southern part of Indiana.

B. A. Clements, president of the Rome Iron Mills, Inc., has been elected president of the American Arch Company with headquarters at New York, succeeding H. B. Slaybaugh, who has resigned. Lee Deutsch has been elected president of the

Rome Iron Mills, Inc., with headquarters at New York, succeeding Mr. Clements.

Harry L. Shepard, formerly associated with the department of the chemist and engineer of tests of the Union Pacific, has been appointed technical representative in the Chicago territory of the Reading Iron Company, Reading, Pa. The New York City office of the Reading Iron Company was removed on April 22, from 99 John street to 30 Church street; H. S. Carland is district sales representative at New York.

C. R. Naylor has been appointed manager of western sales, with headquarters at Chicago, of the Gould Car Lighting Corporation, to succeed George R. Berger, who has resigned to enter business for himself. The Gould Car Lighting Corporation office has been removed from 32 West Randolph street to 2108 Straus building, Chicago. Mr. Naylor is also manager of western sales, at Chicago, of the Symington Company and the Gould Coupler Company.

F. H. Landwehr, secretary of the Electric Auto-Lite Company, Toledo, has also been elected president of the Prest-O-Lite Storage Battery Corporation, Indianapolis, Ind. J. H. McDuffee, general sales manager of the Prest-O-Lite Company, has been elected vice-president, while J. B. Motley, credit manager of Prest-O-Lite Company, has been elected secretary. J. B. Fenner, formerly associated with Price-Waterhouse Company, New York, has been elected treasurer.

Eric H. Ewertz, one of the founders of the American Welding Society and a past president, has left his position as general manager of the Moore plant of the Bethlehem Steel Company to open an independent consulting engineer's office at 50 Church Street, New York. Mr. Ewertz will deal with problems relating to welding, mechanical and economic engineering. This is probably the only independent consulting engineer's office which makes a specialty of welding problems. Mr. Ewertz is recognized as a pioneer in the welding field, has had wide engineering experience and service rendered will provide the necessary contact between mechanical and welding engineering. Mr. Ewertz, who is a graduate mechanical engineer, has had 30 years' experience in engineering fields, including management of plants employing 9,000 men. Among the companies with which he has been connected are the Navy Yard, Sweden; Schwartzkopf Machine Company, Berlin, Germany; Victor Metals Company, Braintree, Mass.; Bethlehem Steel Company, Elizabeth, N. J., and a number of shipbuilding organizations. His experience covers construction and design of machinery and parts and structural work.

National Bearing Metals Corporation

The National Bearing Metals Corporation has been formed, incorporated under the Laws of New York State, with offices at St. Louis, Mo., and New York, N. Y., through the merger of Bronze Metal Company, New York, More-Jones Brass & Metal Company, St. Louis, Mo., and Keystone Bronze Company, Pittsburgh, Pa.

During the past few months, Bronze Metal Company has acquired the business and properties of Brady Brass Company, Jersey City, N. J., Southern Brass Works, Inc., Portsmouth, Va., and Damascus Bronze Company, Pittsburgh, Pa., all of which now will be operated by, and under the name of National Bearing Metals Corporation, with plants located at the following points: St. Louis, Mo., Pittsburgh, Pa., Meadville, Pa., Jersey City, N. J., and Portsmouth, Va.

The St. Louis office will be at 4930 Manchester avenue, and the New York office at 30 Church street.

The National Bearing Metals Corporation will specialize in the manufacture of railroad engine and car bearings, bronze and brass castings, motor axle and armature bearings, trolley wheels, babbitt metal, etc.

The management of the new corporation will include Alexander Turner, chairman of the board, John B. Strauch, president, Thomas H. Wright, vice-president, Arthur N. Dugan, vice-president, S. W. Crawford, vice-president, W. K. Frank, vice-president, A. Y. Evins, vice-president, R. S. Herman, vice-president, Frank H. Senn, secretary and assistant treasurer, and J. A. Neuwirth, treasurer and assistant secretary.

Personal Mention

General

G. S. GOODWIN, mechanical engineer of the Chicago, Rock Island & Pacific at Chicago, has been appointed assistant to the general superintendent of motive power, with headquarters at the same point.

DANIEL J. AYERS, master mechanic of the Boston & Maine at Woodsville, N. H., has been appointed supervisor of locomotive performance, with headquarters at Boston, Mass., succeeding John W. McVey.

C. F. MORRETT, assistant trainmaster of the second district of the Marion division of the Erie at Huntington, Ind., has been appointed supervisor of locomotive operation on that division with headquarters at the same point.

J. R. VANCE, mechanical inspector of the Gulf Coast lines at Houston, Tex., has been promoted to chief mechanical inspector of the Gulf Coast lines and the International-Great Northern, with headquarters at the same point.

Master Mechanics and Road Foremen

H. W. YATES has been appointed master mechanic of the Rio Grande, Micolithic & Northern, with headquarters at Van Horn, Tex.

H. C. GUGLER, master mechanic on the Chicago, Burlington & Quincy at Sheridan, Wyo., has been transferred to the Hannibal division, with headquarters at Hannibal, Mo.

JOHN W. MCVEY, supervisor of locomotive performance of the Boston & Maine at Boston, Mass., has been appointed master mechanic, with headquarters at East Somerville, Mass.

RALPH E. HAMMOND has been appointed assistant master mechanic of the Fargo division, of the Northern Pacific, with headquarters at Staples, Minn., succeeding E. H. Carlson.

PALMER S. LINDSAY, master mechanic of the Manitoba district of the Canadian Pacific, with headquarters at Winnipeg, Man., has been transferred to Nelson, B. C., succeeding John McFayden.

EDWARD J. DWYER has been appointed master mechanic of the White Mountains-Passumpsic and Connecticut River divisions of the Boston & Maine, with headquarters at Springfield, Mass.

ROBERT P. BLAKE, master mechanic of the Montana division of the Northern Pacific, at Livingston, Mont., has been transferred to the St. Paul division, with headquarters at St. Paul, Minn., succeeding J. B. Neish, granted a leave of absence.

EDMUND H. CARLSON, assistant master mechanic of the Fargo division of the Northern Pacific at Staples, Minn., has been appointed acting master mechanic of the Montana division with headquarters at Livingston, Mont., succeeding Robert P. Blake.

JOHN MCFAYDEN, master mechanic of the British Columbia district of the Canadian Pacific, with headquarters at Nelson, B. C., has been transferred to Vancouver, B. C., succeeding W. H. Evans, retired under persion rules of the company after 46 years' service.

OSCAR NORTON EDMONDSON, who has been appointed master mechanic of the Altoona, Pa., machine shops of the Pennsylvania, was born on June 26, 1884, at Altoona. He is a mechanical engineering graduate of Purdue University, Class of 1911. Mr. Edmondson entered the service of the Pennsylvania on September 1, 1902, as a draftsman, office general superintendent motive power, and from May 1, 1914, to April 22, 1916, was a special apprentice at the Altoona machine shops. On the latter date he became motive power inspector; on December 20, 1916, assistant master mechanic, Juniata shop; and on April 1, 1926, general foreman, Juniata shop.

Car Department

G. E. SNARE, foreman car repairs of the Pennsylvania at Columbia, Pa., has been appointed shop foreman with headquarters at Lucknow, Pa.

G. E. Lund, master mechanic of the Erie at Huntington, Ind., has been appointed assistant superintendent of the car department, with headquarters at Huntington.

E. M. Jenkins, who has been appointed master car builder of the Delaware, Lackawanna & Western at Scranton, Pa., was born on June 28, 1886, at Vermont, Ill., and was educated in the schools of his native town and the University of Illinois. From July, 1909, to September, 1911, he was a special apprentice with the Baldwin Locomotive Works. From the latter date until July 1, 1926, he was successively draftsman with the Baltimore & Ohio; chief draftsman, Seaboard Air Line; mechanical engineer, Virginian; and special mechanical inspector, Chesapeake & Ohio. On July 1, 1926, he became chief draftsman, car department of the D. L. & W.

Shop and Engine House

J. E. Carroll has been appointed tool supervisor of the Chesapeake Ohio, with headquarters at Huntington, W. Va.

H. H Vanderbosh has been appointed enginehouse foreman of the Baltimore & Ohio, with headquarters at Garrett, Ind., succeeding J. B. Harward.

G. E. Francis, general foreman of the Pennsylvania at East Altoona Pa., has been promoted to general foreman of the erecting and machine shop, Juniata, Pa.

W. H. Witherspoon has been appointed night enginehouse foreman of the Baltimore & Ohio, with headquarters at Garrett, Ind., succeeding H. H. Vanderbosh.

C. E. Hoffman, enginehouse foreman of the Pennsylvania at Allegheny, Pa., has been promoted to general foreman at East Altoona, Pa., succeeding G. E. Francis.

M. W. Rauschenberger, enginehouse foreman of the Union Pacific at Cheyenne, Wyo., has been appointed general foreman, with headquarters at North Platte, Neb.

J. E. Payton, assistant enginehouse foreman of the Union Pacific at Cheyenne, Wyo., has been promoted to the position of enginehouse foreman with headquarters at the same point, succeeding M. W. Rauschenberger.

Purchases and Stores

A. E. Owen, assistant purchasing agent of the Pennsylvania, with headquarters at Chicago, has been appointed also purchasing agent of the Chicago Union Station Company, Chicago, succeeding W. G. White, Sr., who will continue in his capacity as secretary. Mr. Owen was born on March 27, 1880, at Camden, N. J., and entered railway service in April, 1896, in the office of the auditor of passenger receipts of the Pennsylvania at Philadelphia. In June, 1899, he was transferred to the purchasing department, where he held various positions until 1914, when he was designated to represent the purchasing department with Gibbs and Hill, consulting electrical engineers on the Philadelphia, Paoli and Chestnut Hill electrification. Following this work in 1917, Mr. Owen was appointed chairman of a committee which was placed in charge of the management and the supplying of commissaries of labor camps on the Pennsylvania lines east of Pittsburgh and Buffalo. Two years later he was promoted to equipment agent, becoming assistant to the purchasing agent of the Northwestern region at Chicago in March, 1920. In February, 1924, Mr. Owen was promoted to assistant purchasing agent, the position he held at the time of his further appointment as purchasing agent of the Chicago Union Station Company.

A. E. Owen

J. L. Bracken, engineering assistant on the New York, New Haven & Hartford at New Haven, Conn., has been appointed assistant to the mechanical superintendent of the New York division, with headquarters at New York City.

Heber O. Wolfe, who has been appointed general storekeeper of the Chicago & Alton, with headquarters at Bloomington, Ill. was born on May 18, 1900, at Corydon, Ind. After attending high school at Corydon, Mr. Wolfe entered railway service at the age of 16 as a helper in the car department of the Alton at Bloomington. During the same year he was transferred to the stores department where he served in various capacities until September, 1919, when he was promoted to chief clerk to the storekeeper at the same point. In August, 1920, Mr. Wolfe was advanced to general foreman, becoming traveling storekeeper in August of the following year. After nearly five years in this position, on February 1, 1926, he was promoted to assist general storekeeper where he remained until his further promotion to general storekeeper.

H. O. Wolfe

Obituary

William H. Richmond, master mechanic of the Lake Superior & Ishpeming from 1899 to 1919, died at Marquette, Mich., on June 13, aged 77 years.

Charles D. Barrows, purchasing agent of the Maine Central, with headquarters at Portland, Me., died on May 12 after an illness of several weeks. Mr. Barrows was born on November 12, 1871, at Lowell, Mass. He later moved to San Francisco, Cal., where he received his early education. In 1889 he came east and entered Dartmouth College from which college he was graduated in 1894. On November 12 of the same year he entered the service of the Maine Central as a clerk in the offices of the general passenger agent. On November 16, 1895, he was transferred to the supply department, and was appointed purchasing agent on August 1, 1898, which position he was holding at the time of his death.

C. G. Juneau, master car builder of the Chicago, Milwaukee & St. Paul, died at his home in Milwaukee, Wis., from heart trouble on May 26. Mr. Juneau was born on December 12, 1874, at Milwaukee, and entered railway service with the C. M. & St. P. as a blacksmith apprentice in the car and locomotive departments. He completed this apprenticeship on October 1, 1899, and for the next year he was employed by the Strobel Structure Company, Chicago, as a tool dresser, returning to the car department of the Milwaukee on July 21, 1900. Six years later Mr. Juneau was appointed assistant foreman of the blacksmith shop, where he remained until March 1, 1918, when he was further advanced to general foreman of the car blacksmith department for the entire system. On June 1, 1918, he was promoted to general superintendent of the freight car department, including the blacksmith department, and in March, 1920, he was again promoted to take charge of the Milwaukee terminal and shop district. Mr. Juneau was appointed acting master car builder with headquarters at Milwaukee, on June 1, 1920, becoming master car builder on August 1, a position he held continuously until the time of his death.